FM 24-20

DEPARTMENT OF THE ARMY FIELD MANUAL

FIELD WIRE TECHNIQUE

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This manual supersedes FM 24–20, 4 October 1944, including C 1, 6 March 1945, and the following bulletins: TB SIG 85, 28 August 1944; TB SIG 147, March 1945; TB SIG 176, May 1945; and TB SIG 180, 8 June 1945.

FIELD WIRE TECHNIQUE

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CHAPTER 1

GENERAL

1. PURPOSE AND SCOPE. The purpose of this manual is to establish standard practices for the installation, operation, and maintenance of field wire circuits of tactical units. Standardization is essential to insure efficient wire communication. It is also essential that all wire installations, from the highest to the lowest echelon, combine to form an integrated system. The individual duties of wire personnel of various types of units are explained specifically in training publications pertaining to the different arms. Complete technical information concerning particular items of wire-communication equipment is given in technical manuals listed in FM 21–6.

2. RESPONSIBILITY. a. Commander. Responsibility for signal communication is a function of command (AR 105–15). In general, each commander is responsible for the operation, installation, and maintenance of all means of signal communication within his unit. To that end, the commander relies upon his signal or communication officer for planning and execution.

b. Signal or communication officer. The commander of each tactical unit down to the battalion is provided with a special staff officer trained in the tactics and technique of signal communication. This officer

is responsible to the commander for the tactical supervision of signal communication for the entire command and for the training of communication personnel. In considering plans for any operation, the commander consults the signal or communication officer to determine what signal-communication support can be given each plan proposed. In ground force units the special staff officer in a division or higher headquarters is known as the *signal officer;* in units below the division, he is known as the *communication officer.*

c. Unit. (1) Every unit is responsible for wire communication from its command post to the command post of the next subordinate unit. It may also be responsible for lateral communication. Lateral communication (*signal communication between adjacent units at the same echelon of command*) *is established as directed by the* ***higher*** *commander.* Generally, the highest independent commander engaged in an operation will prescribe whether lateral communication between adjacent units will be from right to left or left to right. A commander may prescribe that his subordinate units provide direct circuits to the units with which they are required to have lateral communication, or he may decide that adequate lateral communication is available by switching through his own headquarters. He may also elect to provide, from facilities connecting his command post to the subordinate command posts, circuits which will give direct communication between the two subordinate command posts. In the case of lateral communication between units which are not immediately subordinate to the same com-

mander, decision as to the method of lateral communication to be employed is made by the first common higher commander.

(2) *The general principle of wire communication in the case of supporting and supported units is that communication is furnished by the* ***supporting unit to the unit supported.*** When the situation demands a variation in the application of this doctrine, the common commander of both supported and supporting units has the responsibility for decision as to what variation should be made.

3. DEFINITIONS. a. Terms pertaining to signal communication in general. (1) *Axis of signal communication.* A line through the probable successive locations of a unit's command post.

(2) *Command post.* The establishment set up by the forward echelon of a headquarters during combat from which tactical control normally is exercised and to which tactical information is sent from subordinate units.

(3) *Message.* All instructions, reports, orders, documents, photographs, maps, or other intelligence, in plain language or in cryptographic text, transmitted by a means of signal communication.

(4) *Message center.* The signal communication agency charged with the receipt, routing, and delivery of official messages. In lower echelon headquarters not served by a signal center, the functions of encrypting and messenger service are included in this title.

(5) *Signal center.* The collection of several agencies and means of signal communication charged with

the responsibility for the receipt, transmission, and delivery of official messages at a military headquarters or echelon. (See FM 24–17.)

(6) *Rear echelon.* A rear installation of a headquarters consisting of those staff agencies which have primarily administrative and supply duties and which are not located at the command post.

b. Terms peculiar to wire communication. (1) *Bridged circuit.* A circuit which is connected in parallel with an existing circuit.

(2) *Circuit diagram.* An illustration in symbol form of the technical arrangement and connections of a wire system.

(3) *Circuit marking tag.* A tag which identifies a field wire or field cable circuit.

(4) *Common battery system.* A telephone system which has current supplied to it from a central source.

(5) *Construction center.* An installation, located near or in a command post area, where trunks and local circuits converge for entrance to the telephone central.

(6) *Construction chief.* A noncommissioned officer in charge of the installation and maintenance of the trunk and long local circuits in the wire system of his unit.

(7) *Cross.* An electrical contact between conductors of two independent circuits.

(8) *Fault.* A fault is a defective point in a wire circuit due to grounding, a break in the circuit, or a crossing or shorting of wires.

(9) *Field telephone.* A portable telephone designed for field use.

(10) *Field telephone switchboard.* A portable telephone switchboard designed for field use.

(11) *Gaff.* A spur on the inside of pole climbers which is forced into the pole by the weight of the lineman.

(12) *Ground (on a line).* An electrical path to earth from one or both conductors of a wire circuit.

(13) *Line route map.* A map, map substitute, or overlay on which is shown the physical location of wire circuits that are already installed or are to be installed.

(14) *Loading coil.* A specially designed coil of wire used to increase the talking range of a field wire line by increasing the inductance of the circuit and thereby counteracting the capacitance of the circuit.

(15) *Local.* A wire circuit connecting a telephone to a switchboard or to another telephone.

(16) *Local battery system.* A telephone system in which the current for talking is supplied at each telephone, sometimes called a magneto system.

(17) *Magneto.* A hand-operated, a-c generator used to operate telephone ringers and switchboard line indicators.

(18) *Maintenance pool.* A centrally located area from which wire maintenance crews may be sent out quickly to clear trouble on the system.

(19) *Marline.* A small, loosely twisted twine used for tying field wire to a support.

(20) *Monocord switchboard.* A field telephone switchboard in which each line terminates in a single jack and plug.

(21) *Open.* A break in the continuity of a wire circuit.

(22) *Repeater.* A device for amplifying the strength of a signal in a wire circuit in order to increase the range of the circuit.

(23) *Repeating coil.* A transformer of approximately one-to-one ratio, used to separate physically two circuits in respect to direct current, to match impedances and to permit the formation of simplex and phantom circuits.

(24) *Section of a wire line.* That portion of a wire line which begins and terminates at successive centrals, at test stations, or (in the case of long locals) at a telephone.

(25) *Seizing wire.* Soft-drawn copper wire used to improve field-wire splices mechanically and electrically.

(26) *Short.* An electrical contact between the two conductors of a wire circuit.

(27) *Sidetone.* The audible sound produced in a telephone receiver when the transmitter of the same telephone is actuated by sound waves.

(28) *Skinning.* The process of removing insulation from wire.

(29) *Staggering.* The spacing of splices in the two conductors of twisted-pair wire so that the individual splices will not be opposite each other, thus preventing excessive bulk and reducing the probability of shorts.

(30) *Switching central.* An installation in a wire system where telephone or teletypewriter switchboards are installed to interconnect telephone or teletypewriter circuits.

(31) *Telephone directory.* A list of names and

numbers assigned telephnes and switchboards within a unit.

(32) *Teletypewriter.* A motor-driven machine, similar to a typewriter, which transmits electrical impulses corresponding to a printed character and translates such impulses into the same printed character.

(33) *Terminals.* Conveniently arranged contacts or binding posts to which wires may be quickly connected.

(34) *Terminal equipment.* Telephone and teletypewriter switchboards and other centrally located equipment to which wire circuits are terminated.

(35) *Terminal strip.* A block of insulating material to which are fastened several binding posts.

(36) *Test station.* An installation where circuits may be tested and rearranged.

(37) *Trunk.* A wire circuit connecting switchboards.

(38) *Way station.* A teletypewriter connected to a line between and in series with other teletypewriter stations.

(39) *Wire chief.* A noncommissioned officer in charge of the installation, operation, and maintenance of short locals, the switchboard, and auxiliary equipment.

(40) *Wire pike.* A pole about 9 feet long with a wire hook arrangement on one end used to place field wire lines off or on a road, or to lift wire over limbs of trees or other obstructions.

4. COMPOSITION OF WIRE SYSTEMS. The wire system of a tactical unit consists of telephone, tele-

typewriter, and facsimile facilities. The wire system is installed by communication or Signal Corps personnel assigned to the headquarters of that unit, or by a Signal Corps organization which is attached to that unit. It includes as much of the following equipment as is necessary to meet the requirements for wire communication:

a. Wire lines and associated loading and repeating equipment.

b. Connecting equipment installed at construction centers.

c. Switching and terminal equipment installed at switching points along wire lines.

d. Testing equipment installed at test stations, construction centers, and switching installations.

e. Station equipment, including telephones, teletypewriters, and facsimile equipment serving various elements of the unit headquarters.

5. CLASSIFICATION OF WIRE CIRCUITS. a. According to use. Wire circuits are classified according to use as follows:

(1) *Trunk* circuits or trunks which connect switching centrals.

(2) *Local* circuits or locals (sometimes called loops) which connect telephones to telephone centrals or other telephones.

b. According to electrical path. Wire circuits are also classified according to the path provided for the electrical current, as follows:

(1) *Ground-return* circuits, in which the metallic conductor furnishes only a part of the path for the electric current, the return path being provided by the earth.

(2) *Metallic* circuits, in which the path for the electric current is completed through the metallic conductors. The metallic circuit has proved to be more satisfactory for telephone communication than has the ground-return circuit. It is less susceptible to interference from other circuits and earth currents.

c. When superimposed on other circuits. Additional circuits may be superimposed upon metallic circuits by the use of repeating coils; when this is done, the circuits are classified as follows:

(1) A single metallic telephone circuit may provide an additional telephone or teletypewriter circuit without mutual interference. The additional circuit uses a ground return and is known as a *simplex circuit*, and the metallic circuit is said to be simplexed.

(2) Two metallic telephone circuits may provide an additional telephone or teletypewriter circuit without mutual interference. This third circuit is called a *phantom circuit*. The two metallic circuits are called *side circuits* to distinguish them from the phantom circuit; the three together are known as a phantom group. Such a connection is used in preference to the ground-return simplex circuit, because it provides greater signal security than is provided by a simplex circuit. The phantom circuit of a phantom group can be simplexed.

6. MOVEMENT OF COMMAND POSTS. The maintenance of wire communications is usually more difficult during the movements of command posts than at any other time. The initial installation of each wire system is planned with the object of maintaining continuous wire communication with subordinate

units during and after the movement of command posts. In the overland displacement of command posts, one or more construction teams may be assigned to extend axial lines forward from subordinate headquarters. These teams install lines to points on the wire axis, which are the locations of probable future command posts, in order that the wire lines may be ready for service on the forward displacement of the command post. Using the construction teams in this manner places them in position to deal most effectively with new installations, trouble shooting in either direction on existing lines, or for emergency work with the lower echelon teams. In some instances as many as five echelons or as few as one echelon may be operated by a single headquarters. To insure continuity of communications each echelon remains in operation until its forward displacement is completed.

7. ORDERS AND INSTRUCTIONS. In corps and higher units, instructions concerning the wire system for a particular operation usually are included in a signal annex to a field order. In divisions and below, the corresponding instructions usually are issued orally. However, the plan of installation can best be shown by use of a circuit diagram and a line route map (pars. 8, 9, and 10).

8. CIRCUIT DIAGRAM. a. Definition. An illustration in symbol form of the technical arrangement and connections of a wire system.

b. Content. A circuit diagram indicates the following:

(1) Switching centrals at command posts and at establishments served by the wire system; commercial switching centrals; test stations; and long local telephone circuits (that is, circuits to local telephones not in the immediate vicinity of a switching central). These are shown by special symbols (par. 11) and by telephone directory names or numbers. Locations are indicated by the names of map or terrain features. (The commander of the theater of operations may prohibit the use of map locations, unit designations, or symbols when signal security is jeopardized.)

(2) Number of circuits, including trunks and long locals, between the command posts or establishments shown.

(3) Number assigned to each circuit (par. 9).

(4) Manner of connecting each circuit into or through switching centrals and test stations, including the connections for simplex and phantom circuits.

(5) Type of line construction used for each line, such as field wire, open wire, cable, commercial circuits, etc.

9. DESIGNATING LINES AND CIRCUITS. **a.** Wire lines and circuits are given individual designations, as published in orders by higher authority.

b. In division wire systems, circuits may be designated by individual number, by code name, or by a combination of the two.

c. In assigning numbers to wire circuits, no two cables or circuits, constructed by the same organization during a single operation, are given the same number.

d. The wire system should be as simple as possible to facilitate marking and identification. This is done in figure 1 by using the code name of the unit being served combined with a number. For example, Firestone Switch 1, 2, 3, and 4 are four trunks from Telephone Central at 4th Division Command Post to 4th Division Switching Central. Foot 1 and 2 identify the two circuits from Firestone Switch to Foot. A similar circuit designation is used for Fleet and Floss circuits. Long locals, such as the line from 4th Division to OP1, are identified by the code name and number of the using unit, that is, Firestone 105. Note that the designation of a circuit is the same from beginning to end, regardless of test stations that it may pass through.

10. LINE ROUTE MAP. a. General. A line route map is a map, map substitute, or overlay, suitably titled, on which is shown the actual or projected routes of wire circuits. A line route map does not show the actual connections at switching centrals or test stations (fig. 2). The principal use of a line route map is to report the physical location of wire circuits as actually laid. This information is for the use of wire personnel. On an overlay at least two orientation points taken from a map must be shown and reference made to the map used (unless the commander of the theater of operation directs otherwise). The line route map contains as few lines, symbols, and notations as are necessary for clarity. It shows the location of each headquarters or establishment served by the wire system; locations of switching centrals, test stations, and long locals; the

ANNEX NO.1 TO ANNEX NO. 3 TO FIELD ORDER NO.6, 4TH INFANTRY DIVISION
CIRCUIT DIAGRAM, 4TH INFANTRY DIVISION
EFFECTIVE 0001Q, 1 DEC 1943

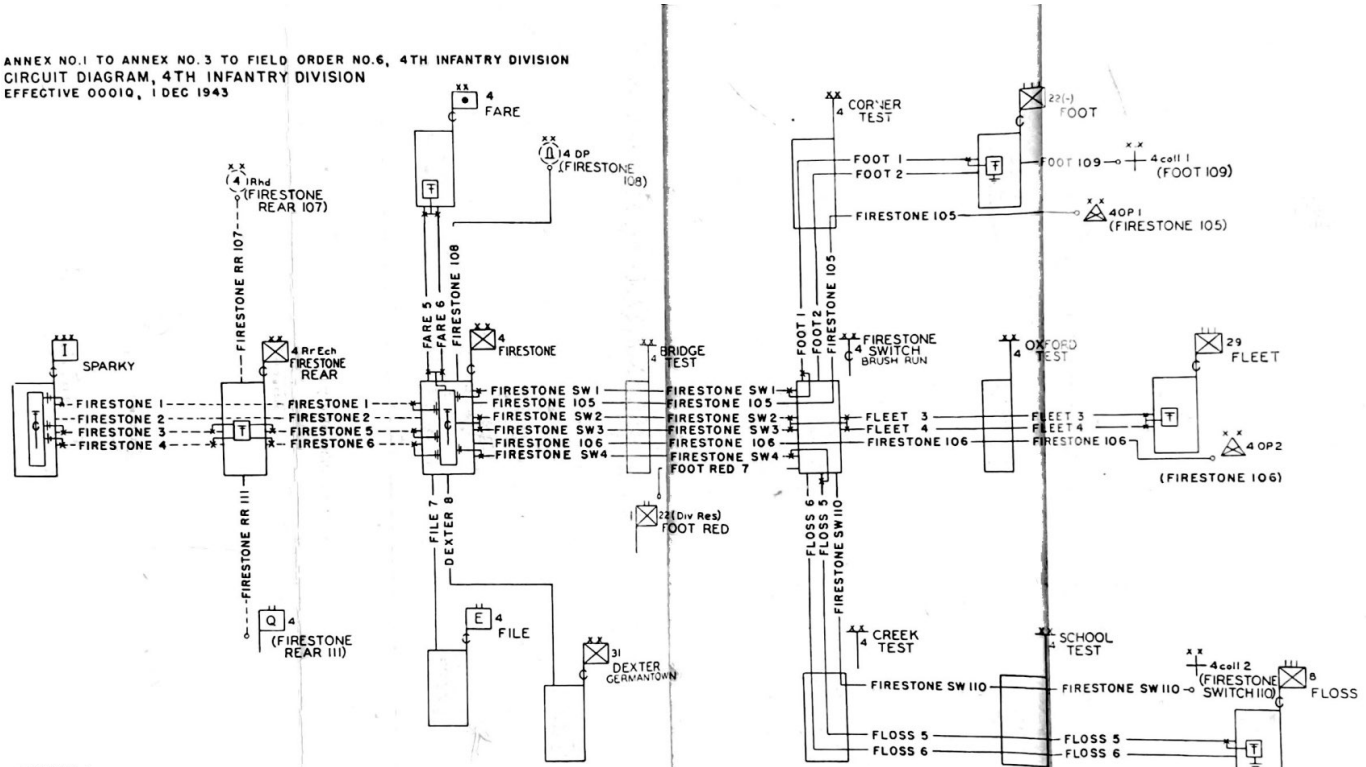

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Figure 1. Example of circuit diagram.

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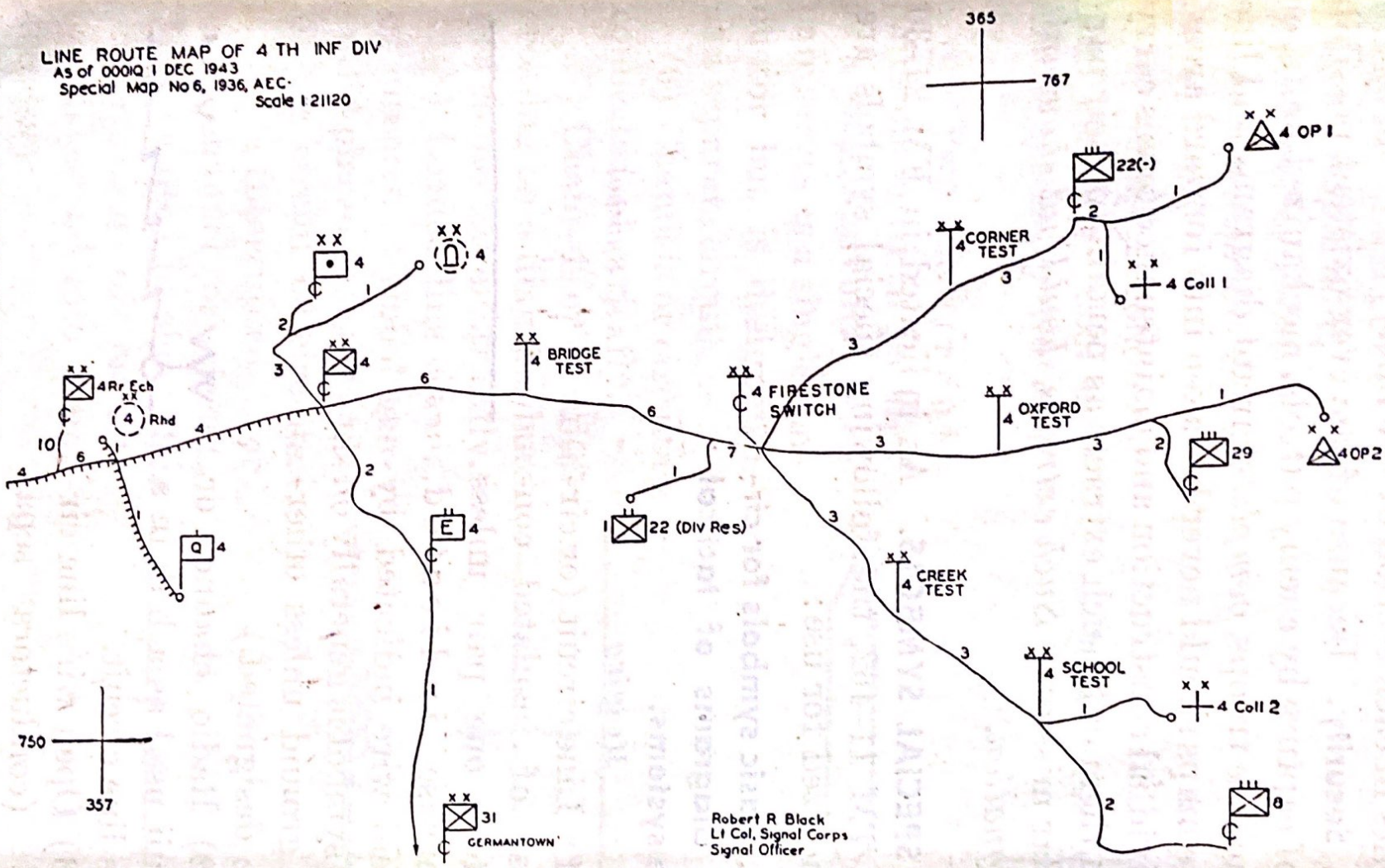


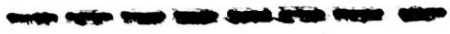
Figure 2. Example of a line route map.

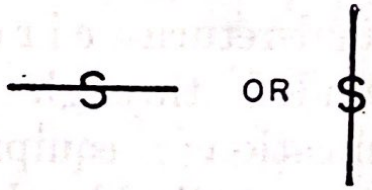
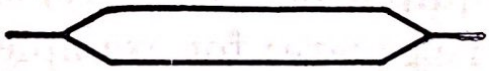
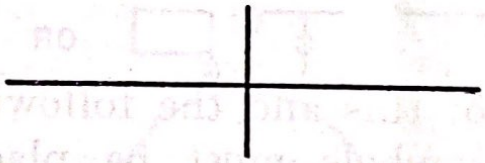
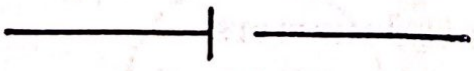
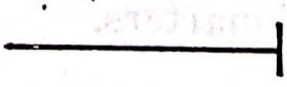
type of construction; and the number of physical circuits in each section of the line.

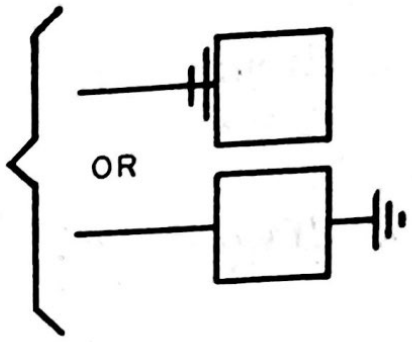
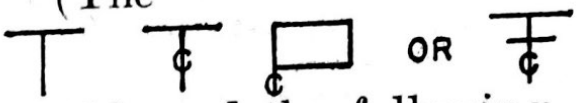
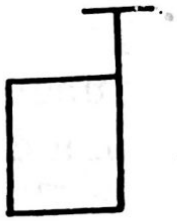
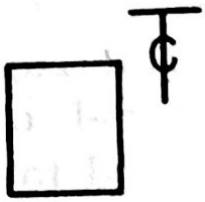
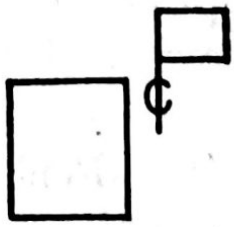
b. Security. Because of the ever-existent possibility of capture by enemy patrols, mechanized units, or parachute troops, *complete* circuit diagrams and line route maps should never be taken into forward areas. Individual construction and maintenance teams carry with them only such extracts as pertain to their particular mission. *Such extracts should not show unit designation.*

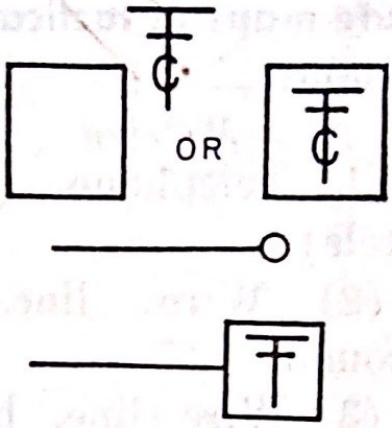
11. SPECIAL SYMBOLS. As indicated in FM 21–30 and TM 11–462, the following special symbols are authorized for use:

a. Basic symbols for circuit diagrams of tactical wire systems.

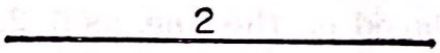
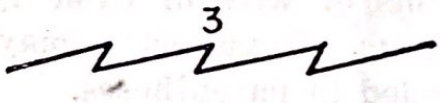
Meaning	*Symbol*
(1) Line circuit (or circuits) of insulated conductors, one pair unless otherwise indicated. (Field wire indicated by this symbol is generally on the ground unless otherwise designated.)	
(2) Radio channel or circuit used as a link in a wire line circuit.	
(3) Open wire line circuit (conductors separately supported on insulators and overhead sup-	

Meaning	*Symbol*
ports), one pair unless otherwise indicated. *Where applicable, this symbol will be substituted for the basic symbol in* (1) *above.*	
(4) Single conductor line circuit. Use only where necessary for clarity.	
(5) Two line-circuit pairs operated in parallel as a single circuit. Each pair serves as a single conductor but is designated as a separate circuit.	
(6) Channels or circuits connected electrically.	
(7) Channels or circuits crossing on a diagram but *not* connected electrically.	
(8) Loaded line circuit or circuits. Symbol generally placed near the ends of the circuit or circuits.	
(9) Interrupted (or cut) channel or circuit. May be used to show the interruption of circuits which extend into enemy territory.	
(10) Dead-ended channel or circuit.	

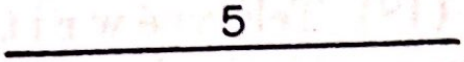
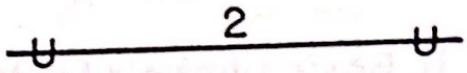
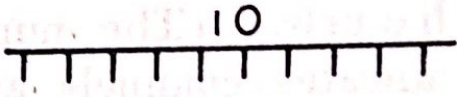
Meaning	*Symbol*
(11) Repeating coil (simplex coil) on a line circut. The simplex leg is shown at right angles to the through line circuit.	
(12) Single-conductor ground-return circuit grounded through communication equipment. Where applicable, the appropriate symbol for the equipment will replace the square; for example, a small circle for a telephone.	
(13) Cable terminal or test station. (The  of this and the following symbols must be placed within, close to, or connected to the rectangle, so that the meaning is clear.)	
(14) Telephone central *not* at a command post or headquarters.	
(15) Telephone central at a command post or headquarters.	

Meaning	*Symbol*
(16) Teletypewriter switching central.	
(17) Telephone or telephone set.	
(18) Teletypewriter (page printing).	

b. Basic symbols for traffic diagram of tactical wire systems.

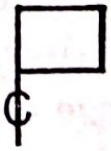
Meaning	*Symbol*
(1) Direct channel or channels. (The number indicates channels available.)	
(2) Direct radiotelephone or teletype channel.	
(3) Telephone or telephones (small circle).	
(4) Telephone central (large circle).	
(5) Teletypewriter (page printing).	
(6) Teletypewriter central, switching, manual, or relay (large circle). (Include equipment identifying symbol within circle.)	

c. Basic symbols for line route maps of tactical wire systems.

Meaning	*Symbol*
(1) Telephone (small circle).	
(2) Wire line, on ground.	
(3) Wire line, buried or underground.	
(4) Wire line, aerial (on overhead supports).	

Note. The number of *physical pairs* in a wire line is indicated by a small number placed on the line, as 5, 2, and 10 above. If desirable, additional appropriate designations of wire or cable types, sizes, or material may be added in parentheses.

d. Basic symbols for military organizations and installations.

Meaning	*Symbol*
(1) Test station or cable terminal.	
(2) Telephone central *not* at a command post or headquarters.	
(3) Telephone central at a command post or headquarters.	
(4) Teletypewriter switching central.	

Meaning

(5) Message center.

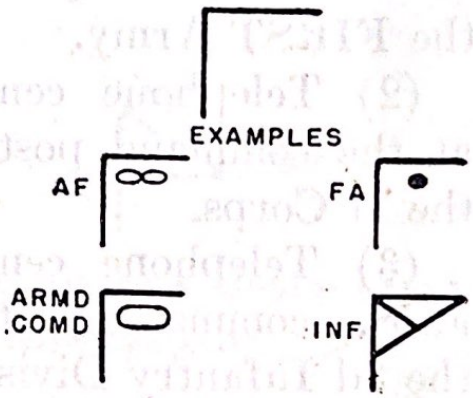
(6) Point on the axis of signal communication (probable future location of a command post or headquarters).

Note. This symbol is intended to be one-half of the rectangle of the basic symbol for a command post or headquarters, so that it can be completed when the headquarters or command post occupies that location.

(7) Symbols representing commercial installations may be designated by the company name or initials, and/or the abbreviation for "commercial" shown at the right.

Note. The end of the staff of these symbols is drawn to the actual location of the installation on maps or map overlays. There should be a slight space between the end of the staff and any line indicating a wire line on line route maps.

Symbol



COML

e. Applications of basic symbols for military organizations and installations.

Meaning

(1) Telephone central at the command post of the FIRST Army.

(2) Telephone central at the command post of the 11 Corps.

(3) Telephone central at the command post of the 3d Infantry Division.

(4) Telephone central at the command post of the 4th Field Artillery Battalion.

(5) Gettysburg commercial telephone central.

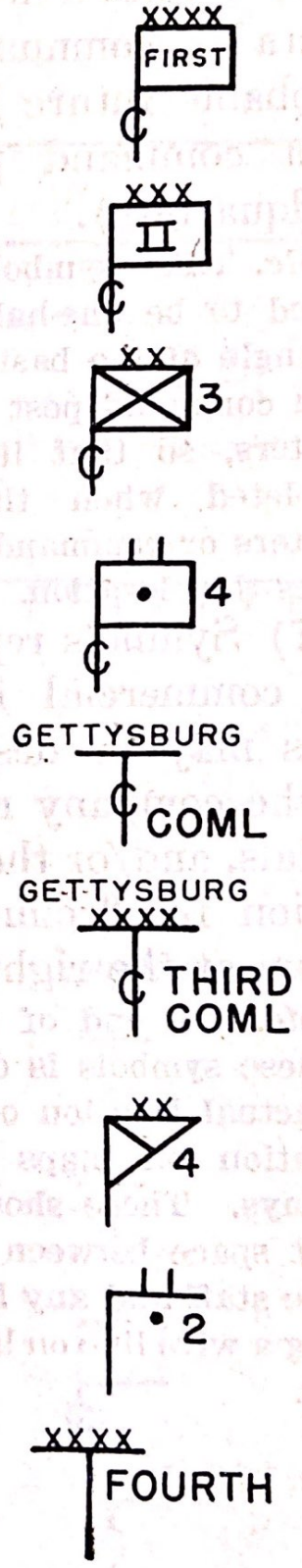
(6) Gettysburg commercial telephone central controlled or operated by THIRD Army.

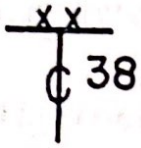
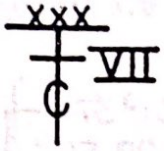
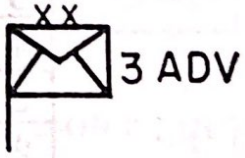
(7) Point on the axis of signal communication of the 4th Infantry Division.

(8) Point on the axis of signal communication of the 2d Field Artillery Battalion.

(9) Test station of the FOURTH Army.

Symbol

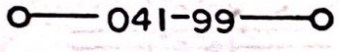
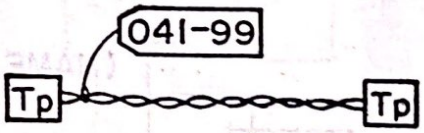


Meaning	*Symbol*
(10) Telephone central of the 38th Division, not at a command post.	
(11) Teletypewriter switching central of the VII Corps.	
(12) Advance message center of the 3d Division.	

f. Application of basic symbols and designations for circuit diagrams of tactical wire systems.

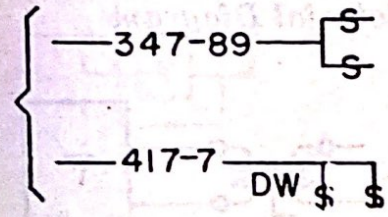
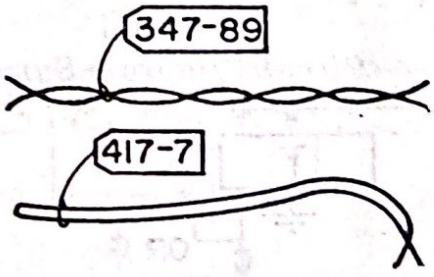
Meaning

(1) Telephones connected together by field-wire circuit 041–99.

Circuit Diagram Symbol	*Pictorial Diagram*
	

Meaning

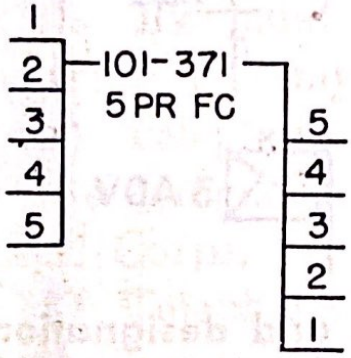
(2) Method of indicating the individual conductors of field-wire circuit 347–89 and drop-wire circuit 417–7.

Circuit Diagram Symbol	*Pictorial Diagram*
	

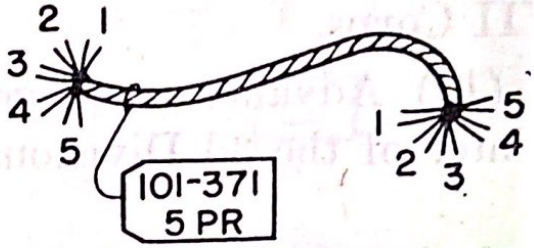
Meaning

(3) Group of five circuits in field cable numb 101–371.

Circuit Diagram Symbol



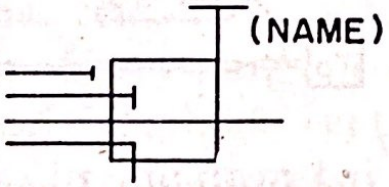
Pictorial Diagram



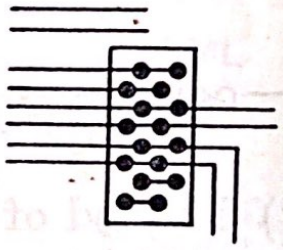
Meaning

(4) Circuits dead-ended close to and at a test-sta tion terminal, and other circuits connected throug that terminal strip.

Circuit Diagram Symbol



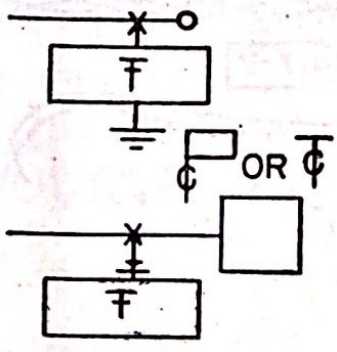
Pictorial Diagram



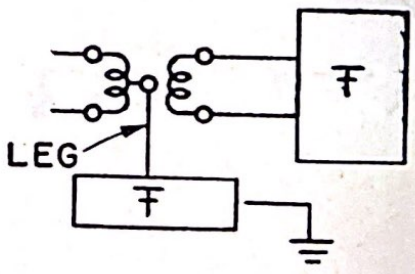
Meaning

(5) Teletypewriter connected to the simplexed circuit of a pair ending at a telephone or telephone central.

Circuit Diagram Symbol



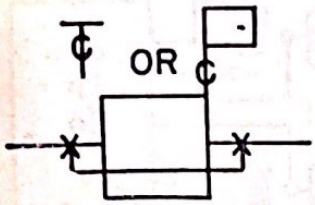
Pictorial Diagram



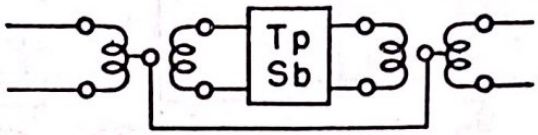
Meaning

(6) Simplexed circuit bridged around a telephone central.

Circuit Diagram Symbol



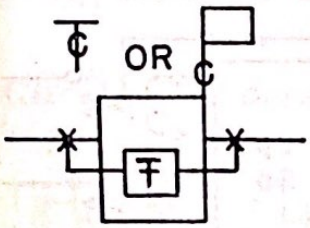
Pictorial Diagram



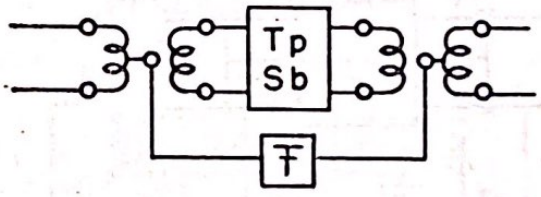
Meaning

(7) Teletypewriter as a way station on a simplexed circuit where the telephone circuits terminate in a telephone central.

Circuit Diagram Symbol



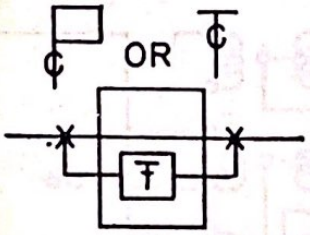
Pictorial Diagram



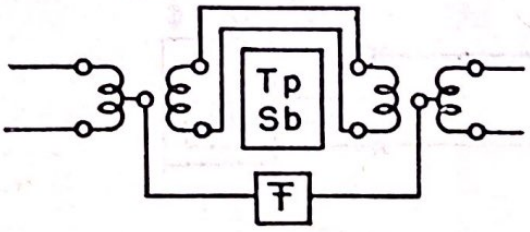
Meaning

(8) Teletypewriter as a way station on a simplexed circuit where the telephone circuit is bridged around the telephone central.

Circuit Diagram Symbol



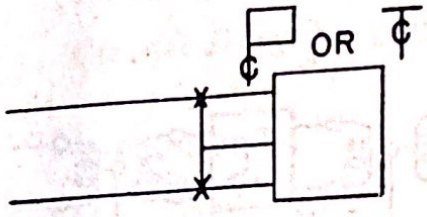
Pictorial Diagram



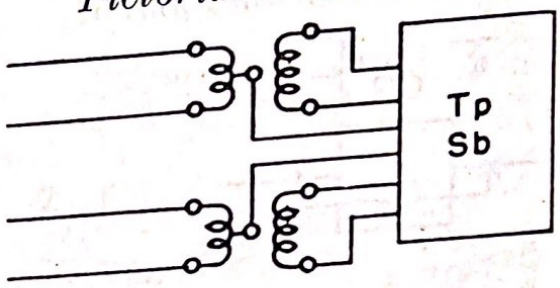
Meaning

(9) Phantom group entering a telephone central.

Circuit Diagram Symbol



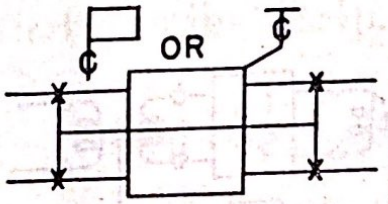
Pictorial Diagram



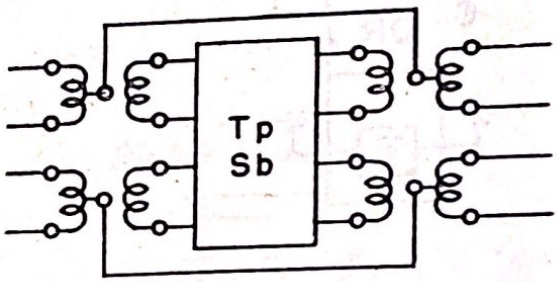
Meaning

(10) Side circuits of two phantom groups entering a telphone central, and the phantom circuit bridged around that central.

Circuit Diagram Symbol



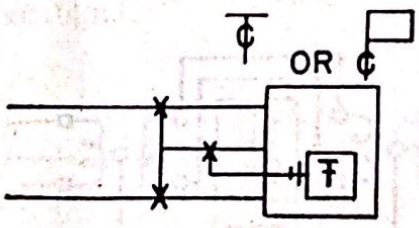
Pictorial Diagram



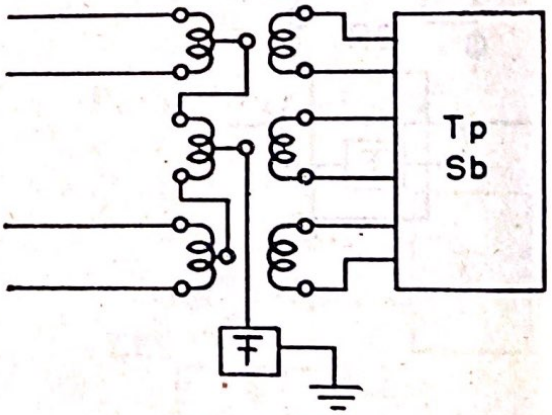
Meaning

(11) Phantom group entering a telephone central with the phantom circuit simplexed for manual teletypewriter operation.

Circuit Diagram Symbol



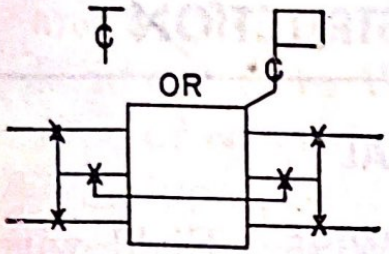
Pictorial Diagram



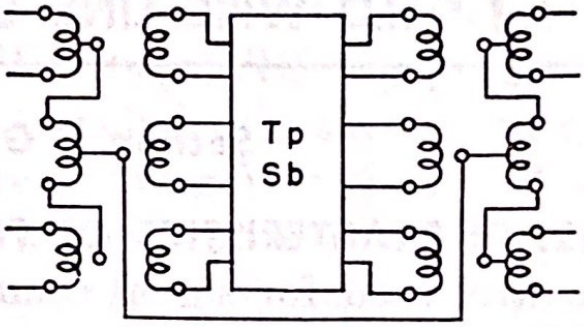
Meaning

(12) Two phantom groups entering a telephone central, with the simplexed circuit on the phantom bridged around the central.

Circuit Diagram Symbol



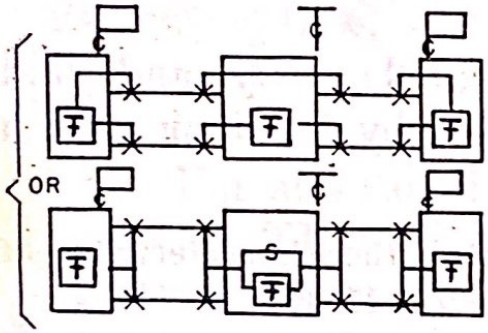
Pictorial Diagram



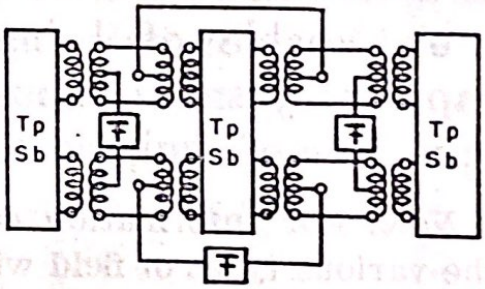
Meaning

(1) Phantom teletypewriter circuit with one way station.

Circuit Diagram Symbol



Pictorial Diagram



CHAPTER 2

FIELD WIRE LINE CONSTRUCTION

Section I. GENERAL

12. CHARACTERISTICS OF FIELD WIRE. Field wi is wire used for signal communication and has th following characteristics:

a. Flexible conductors (usally stranded).

b. Relatively high tensile strength.

c. Good conductivity.

d. Weatherproofed insulation with good resistanc to abrasion.

e. Capable of being handled easily and lai rapidly by small teams, either by hand or with minimum of equipment.

Note. For information concerning the characteristics o the various types of field wire, see TM 11–462.

13. TYPES OF FIELD WIRE AND FIELD CABLE. **a.** Field wire can be divided into two general types. One type has a twisted pair with conductors individually insulated, but without over-all covering; the second type consists of one pair, either parallel-lay or twisted, with an over-all covering. Included in the first type are Wires W–50, W–110–B, W–130–( ), WD–1( )/TT, and WD–14( )/TT. Wires W–110–B and WD–14( )/TT are used mainly by Signal Corps units, the Infantry, Field Artillery,

and Corps of Engineers. Wires W–130–( ) and WD–1( )/TT, often called *assault wire*, are used mainly by the Infantry, Field Artillery, and the Corps of Engineers. Assault wire is lighter, has a lower tensile strength, higher electrical resistance, and less resistance to abrasion. Wire WD–1( )/TT is identical to Wire WD–14( )/TT except for the type of covering used. Included in the second general type of field wire is Wire W–143, a two-conductor, parallel-lay wire with an over-all covering which is used by an arm or service requiring wire for long-distance transmission.

b. Field cable is divided into two general types. The first type includes 5- and 10-pair rubber-covered cables. The second type, spiral-four cable, consists of four spirally twisted conductors covered with a shielding tape, which in turn is covered with a steel wire braid to give mechanical strength, and with an over-all heavy covering of rubber or synthetic rubber. For additional information on 5- and 10-pair cables see TM 11–371; for spiral-four cable see TM 11–369.

14. FIELD WIRE SPLICES. a. General. Splices in a field wire line are vulnerable points in the circuit; therefore, properly made splices require that sufficient time, material, and effort be applied. A poorly made splice creates unnecessary line loss and may unbalance the line to such an extent that it becomes noisy and completely disrupts communication. Since, externally, it usually looks like any other splice in the line, it may require considerable time to find it. Every person engaged in signal communication work

should be able to make a satisfactory wire splice. The ideal goal is to make spliced wire as mechanically strong and as electrically perfect as unspliced wire but, in practice, this goal cannot be attained. Accordingly, the main consideration is to maintain in spliced wire certain characteristics of unspliced wire which are of primary importance. These characteristics include tensile strength, electrical conductivity, insulation resistance, protection against weathering and abrasion, flexibility, and compactness. In attempting to make the splice fulfill these requirements, the time available must be carefully considered.

b. Elements of the wire splice. A wire splice meeting the above requirements consists of a square knot bound with a seizing wire and covered with insulating tape.

(1) *Square knot.* A square knot joining the two ends of a conductor will not pull out.

(2) *Seizing wire.* A flexible field wire of high tensile strength has a number of steel strands which are difficult to manage because of the temper of the wire. The natural tendency of the strands to spring up prevents the splice from remaining tightly wrapped, and the ends of the steel strands tend to puncture the insulation and render the splice unserviceable. To prevent this wrap seizing wire (par. 3**b** (25)) around the conductors after the square knot has been tied, thus keeping the strands in place. The binding effect of the seizing wire on both ends of a spliced conductor, together with the large contact area, produces a splice of high and constant electrical conductivity. Under conditions of variable conductivity,

such as may exist in a splice made with a square knot alone, a circuit becomes noisy and interferes with communication. If a wire conductor is sufficiently flexible, it can be wrapped on a small radius without spreading, and seizing wire can be omitted in a properly made splice, such as the splice described in c below.

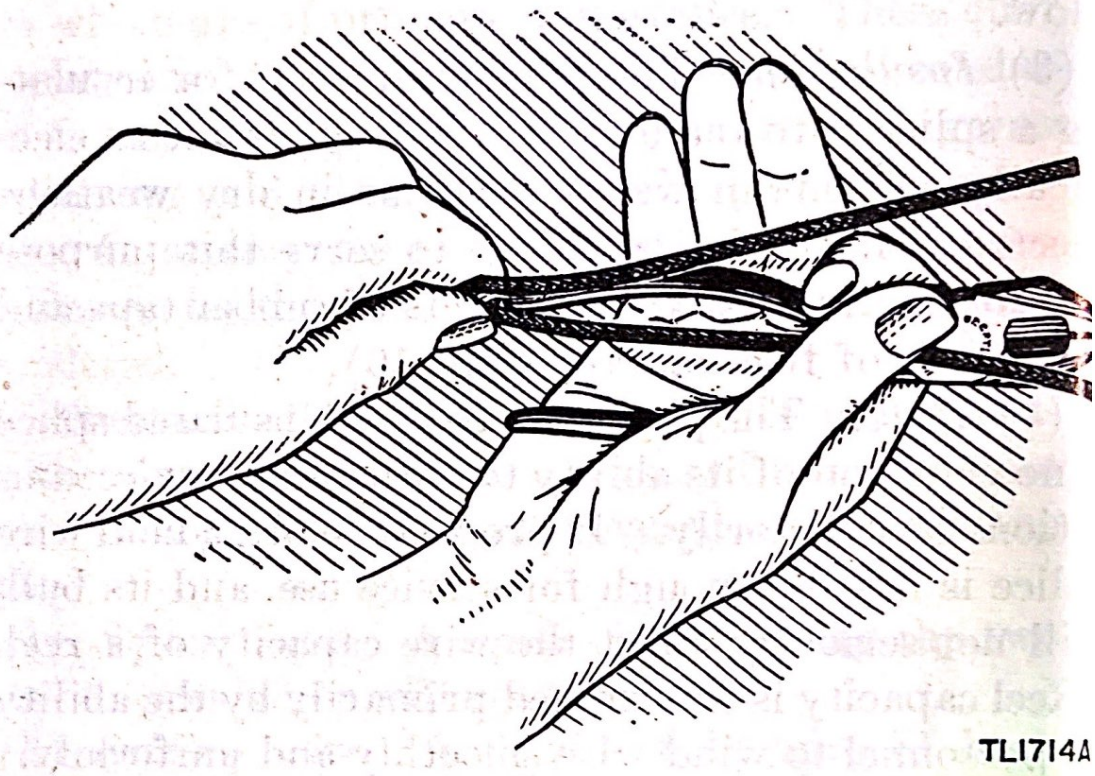
(3) *Insulation.* The primary reason for insulating a splice is to render the resulting circuit as electrically efficient in wet weather as in dry weather. Electrical insulation adequate to serve this purpose requires a minimum of two layers of rubber tape and two layers of friction tape (par. 16).

(4) *Bulk.* The physical size of an insulated splice is no criterion of its ability to withstand service conditions satisfactorily. If properly made, a field wire splice is flexible enough for service use, and its bulk will not seriously affect the wire capacity of a reel. (Reel capacity is determined primarily by the ability of personnel to wind wire smoothly and uniformly.) Usually, extremely bulky splices indicate that the men who made the splice need further training.

c. Standard field wire splice for Wire W–110–B. When two men are available the over-all time needed to make the splice can be reduced greatly if the men have a standardized and efficient method of working together. Only the teamwork splice is described below; obvious modifications of the procedure can be made if one man is working alone.

(1) *Staggering splice* (fig. 3). Each man prepares one of two wires that are to be spliced together. To obtain a uniform stagger that will insure equal tension on both conductors when the splice is com-

pleted, each man measures back one plier's leng (about 6 inches) from the end of one conductor the wire pair he is preparing and cuts off this leng of the conductor. Each man now has two conducto with one cut so that it is one plier's length short than the other.



TL1714A

Figure 3. Staggering splice

(2) *Crushing insulation.* Each man now begins crushing the insulation on the long conductor at a point one plier's length from the end (fig. 4). Using the heel of Pliers TL–13–A (component part of Tool Equipment TE–33), he crushes the insulation toward the end for a distance of about 4 inches, leaving about 2 inches of the insulation uncrushed on the end of the conductor. He next measures back one plier's length along the short conductor and, in a similar manner, crushes about 4 inches of its insulation (fig. 5). The uncrushed insulation remaining on the ends of the conductors holds the strands of the conductors to-

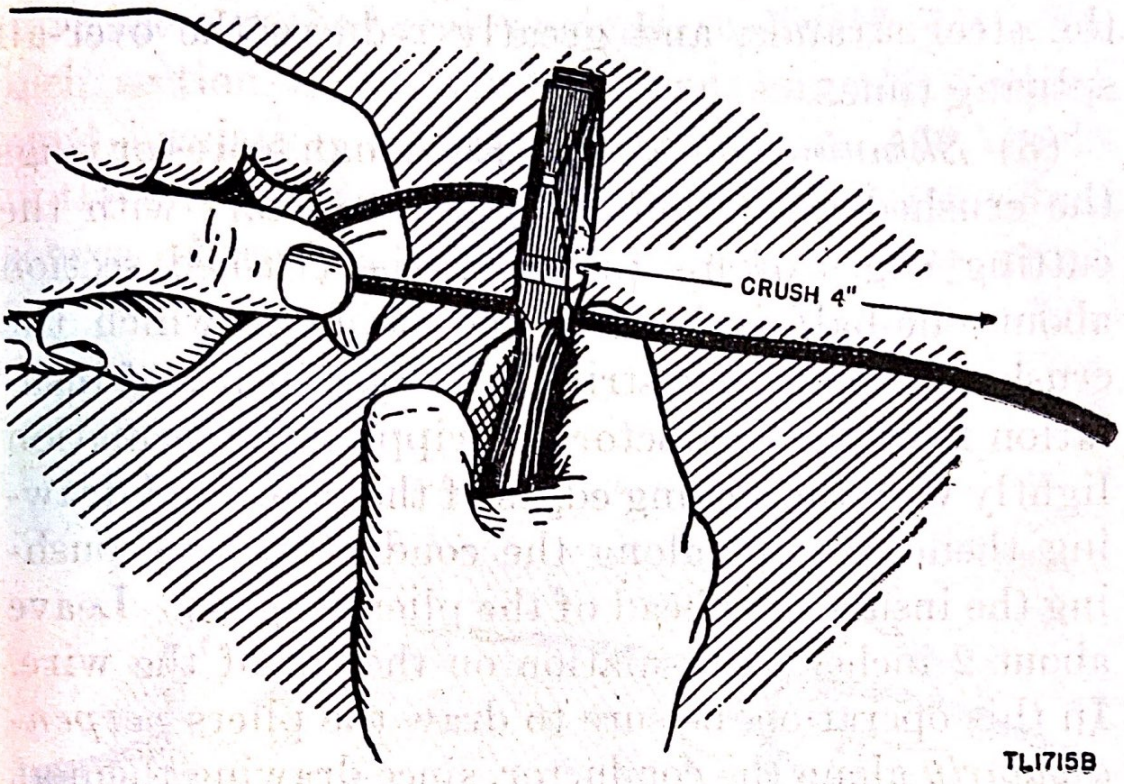


Figure 4. Crushing insulation on long conductor

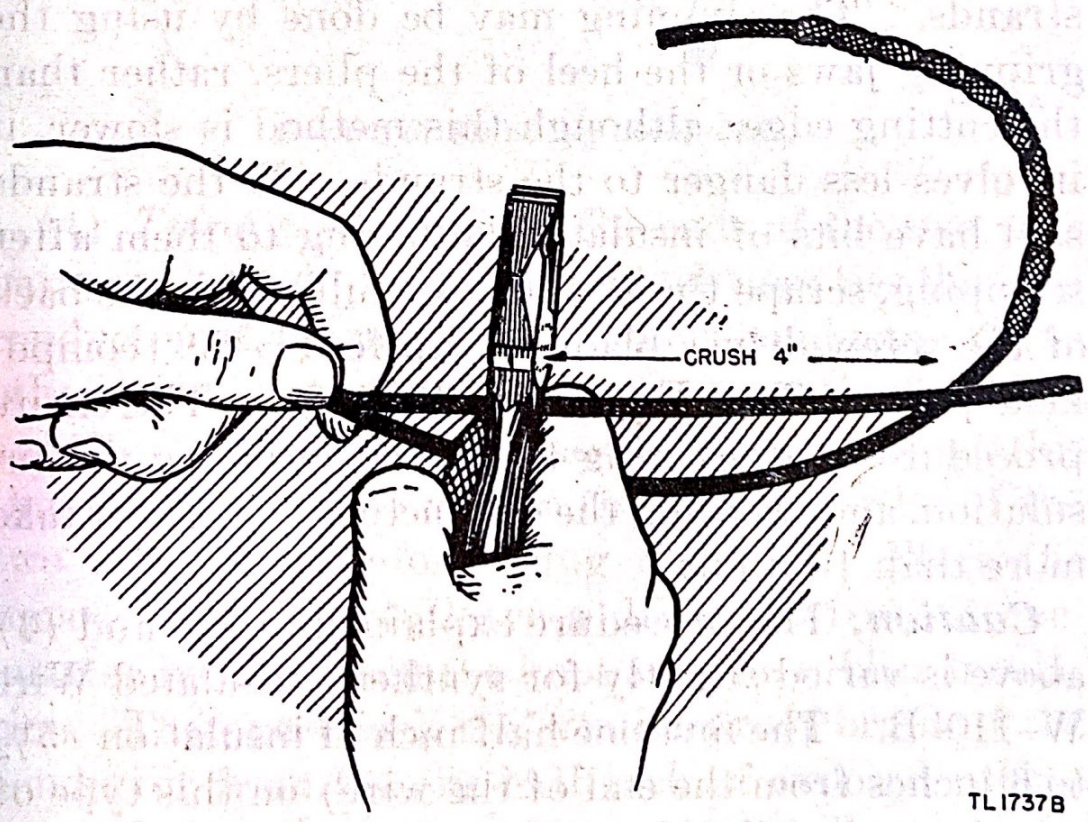


Figure 5. Crushing insulation on short conductor

gether, prevents possible injury to the splicer fro the steel strands, and greatly reduces the over-a splicing time.

(3) *Skinning conductor.* Each man scores or rin the crushed insulation of both conductors with tl cutting edges of his pliers on the crushed sectio about one-half inch from the point at which tl crushing began. He strips about 3½ inches of ins lation from the conductor by gripping the insulatic lightly with the cutting edges of the pliers and dra ing them straight along the conductor, thus pusl ing the insulation ahead of the pliers (fig. 6). Lea about 2 inches of insulation on the tip of the wir In this operation, be sure to draw the pliers *perpe dicularly* along the conductor, since drawing them a any appreciably different angle will nick or break th strands. The skinning may be done by using th gripping jaws or the heel of the pliers, rather than the cutting edge; although this method is slower, i involves less danger to the strands. If the strand still have bits of insulation adhering to them after stripping, scrape the strands carefully with the back of the screw-driver blade of Knife TL–29 (compo-nent part of Tool Equipment TE–33). The entire procedure of staggering the splice, crushing the in-sulation, and skinning the conductors should not take more than 1 minute.

Caution: The procedure explained in (2) and (3) above is varied slightly for synthetic insulated Wire W–110–B. The first one-half inch of insulation (5½ to 6 inches from the end of the wire) on this type of wire is crushed lightly, using only enough pressure to

loosen the braid; then, when the additional 3½ inches have been crushed and removed, the braid on the ½-inch section is pushed back exposing the undamaged insulation. If this is not done, the cracks in the one-half inch of insulation will be a constant source of trouble, especially in wet or damp areas.

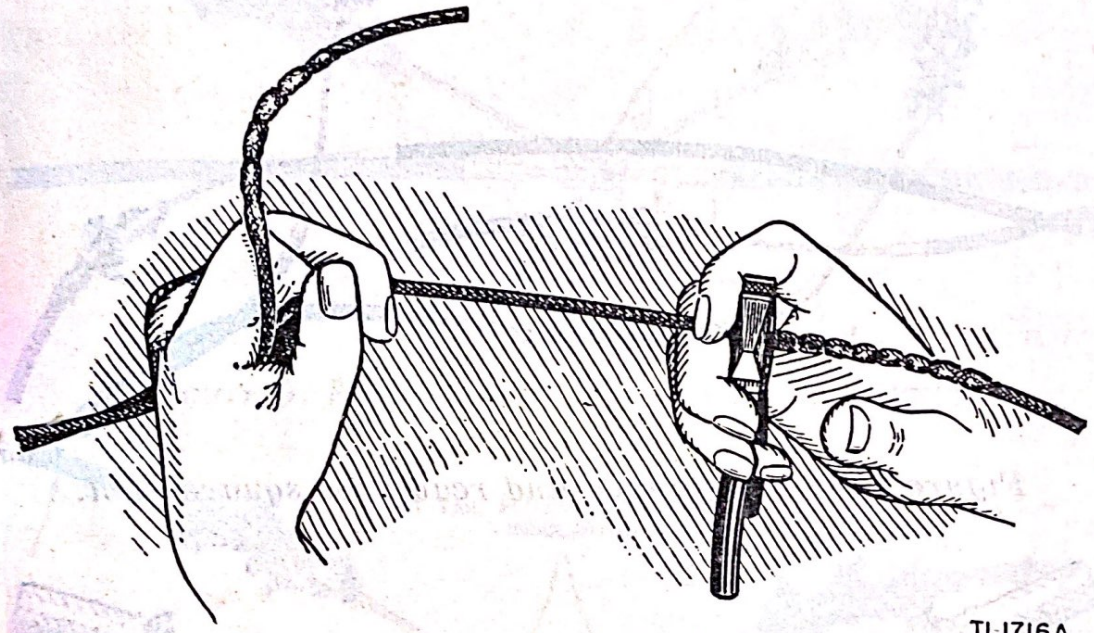


Figure 6. Skinning conductor.

(4) *Tying square knot.* The ends of the two wire pairs are brought together and each man ties the long conductor of one pair and the short conductor of the other pair in a square knot, as shown in figures 7 and 8. The knot is tightened only partially at this time. Be careful to restore the original twist of the two conductors before tying the knot. Place the square knot so as to leave a distance of about one-quarter inch between the knot and the rubber insulation. Then peel back the weatherproof braid of the conductor from the one-half inch of exposed rubber insulation to allow the rubber tape to adhere closely when it is applied.

(5) *Applying seizing wire.* Insert a 6- to 8-in piece of seizing wire through the square knot, a pull the knot tight (fig. 9). Bend the seizing wi so that half can be used for wrapping to the left a

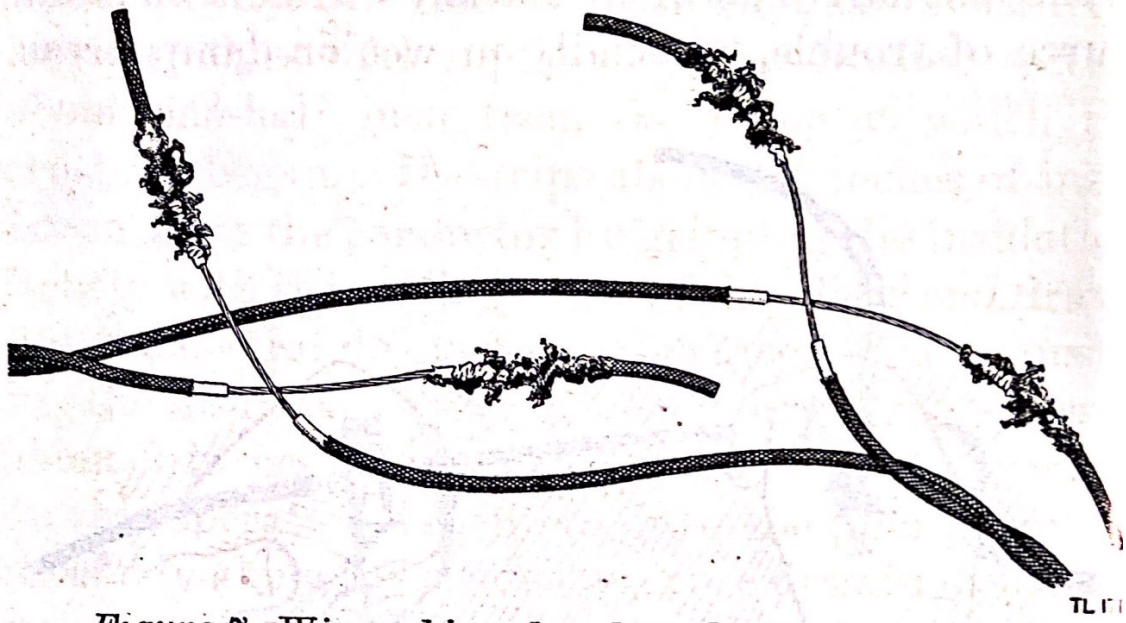


Figure 7. Wires skinned and ready for square knot.

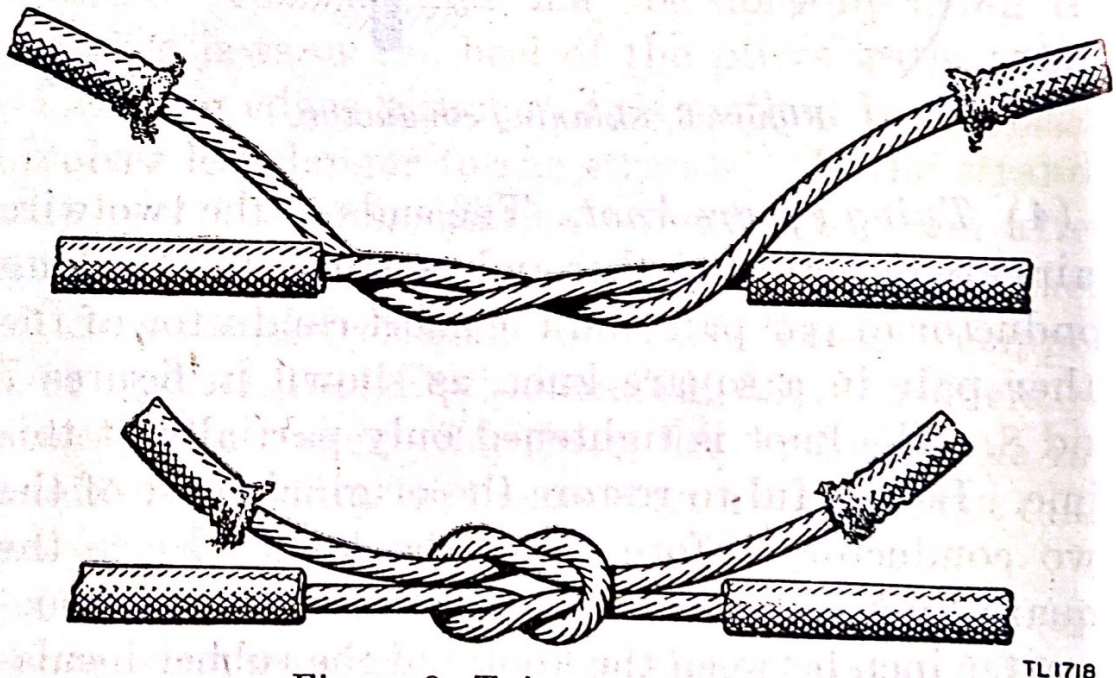


Figure 8. Tying square knot.

half for wrapping to the right. Take 2 or 3 close turns with the seizing wire, both to the left and to the right of the square knot (fig. 10), to bind the knot

before the ends of the line wire are cut off. Then cut the excess ends of the conductors flush with the rubber insulation. Continue the seizing wire wrap, both left and right of the square knot, until 2 turns are taken on the rubber insulation (fig. 11). Now cut off the

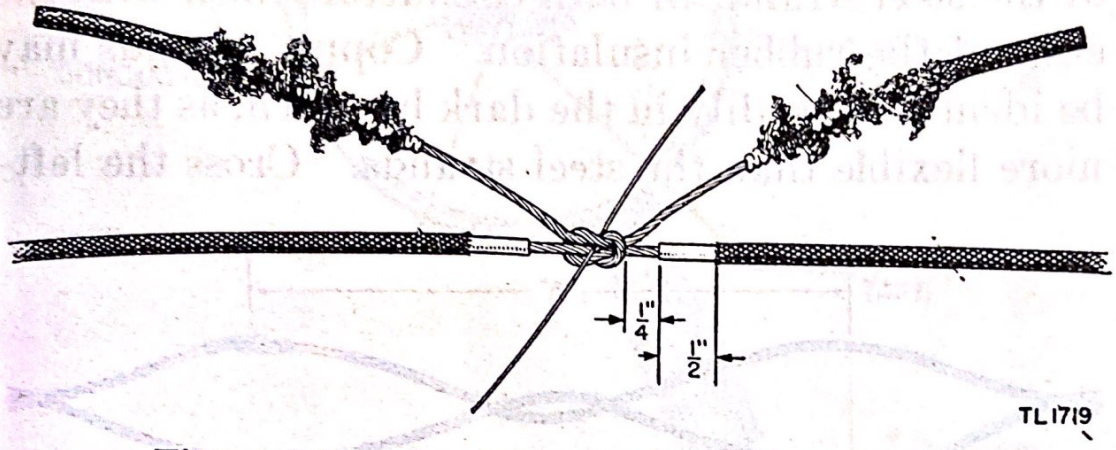


Figure 9. Seizing wire inserted through knot.

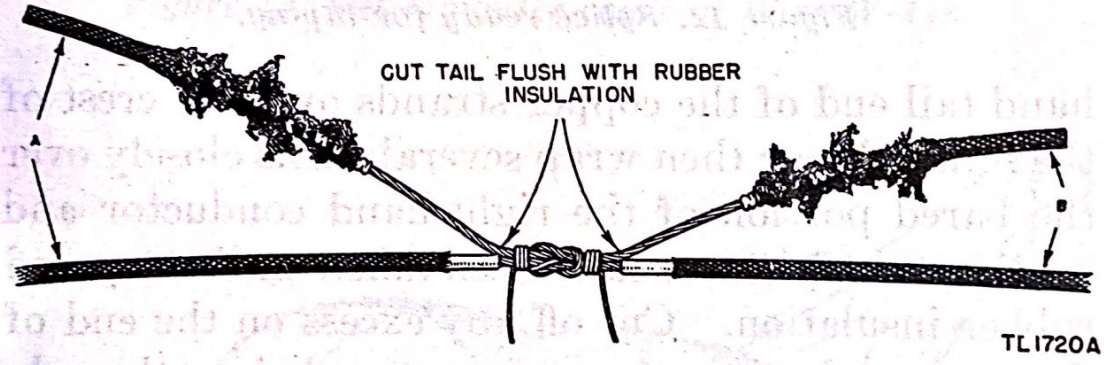


Figure 10. Wrapping seizing wire.

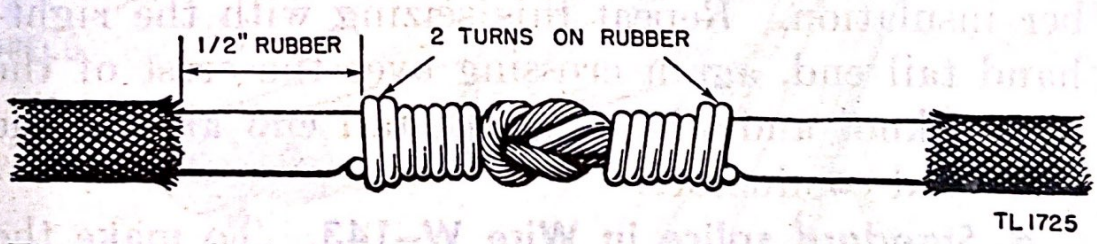


Figure 11. Splice of one conductor after seizing is completed.

ends of the seizing wire and press them down into the rubber. With both men tying the square knots and applying the seizing wire at the same time, the overall time for these operations should be about 1 minute (fig. 12). Tape the splice as described in paragraph 16.

(6) *Seizing without seizing wire.* Where seizi wire is not available, use the copper strands of t conductor to seize the square knot. After the squa knot has been tied and pulled tight, separate the st strands from the copper strands and cut off the en of the steel strands of both conductors flush with t ends of the rubber insulation. Copper strands m be identified readily in the dark by touch, as they a more flexible than the steel strands. Cross the lef

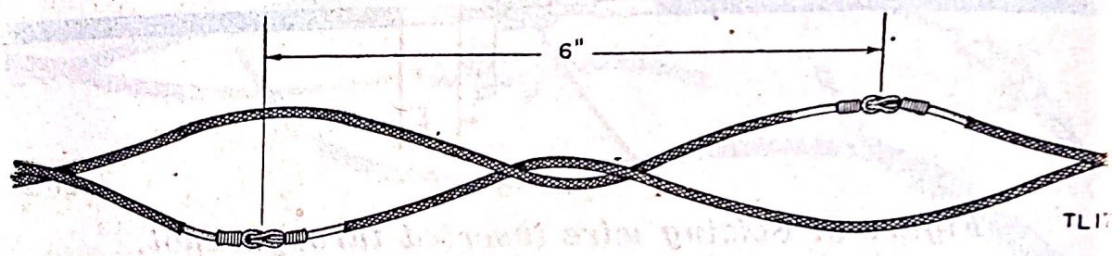


Figure 12. Splice ready for taping.

hand tail end of the copper strands over the crest o the square knot; then wrap several turns closely ove the bared portion of the right-hand conductor an continue until 2 turns have been taken on the expose rubber insulation. Cut off any excess on the end o the wrap and crimp the seizing strands into the rub ber insulation. Repeat this seizing with the right- hand tail end, again crossing over the crest of the square knot and wrapping the tail end around the left-hand conductor.

d. Standard splice in Wire W–143. To make the standard splice in Wire W–143, slit the outer cover with a knife point for a distance of about 6 inches (fig. 13). Do not cut the rubber insulation. Remove the outer cover and shield, leaving the rubber insulation exposed (fig. 14). Nick the rubber web with a knife and split the conductors for 5 inches, leaving

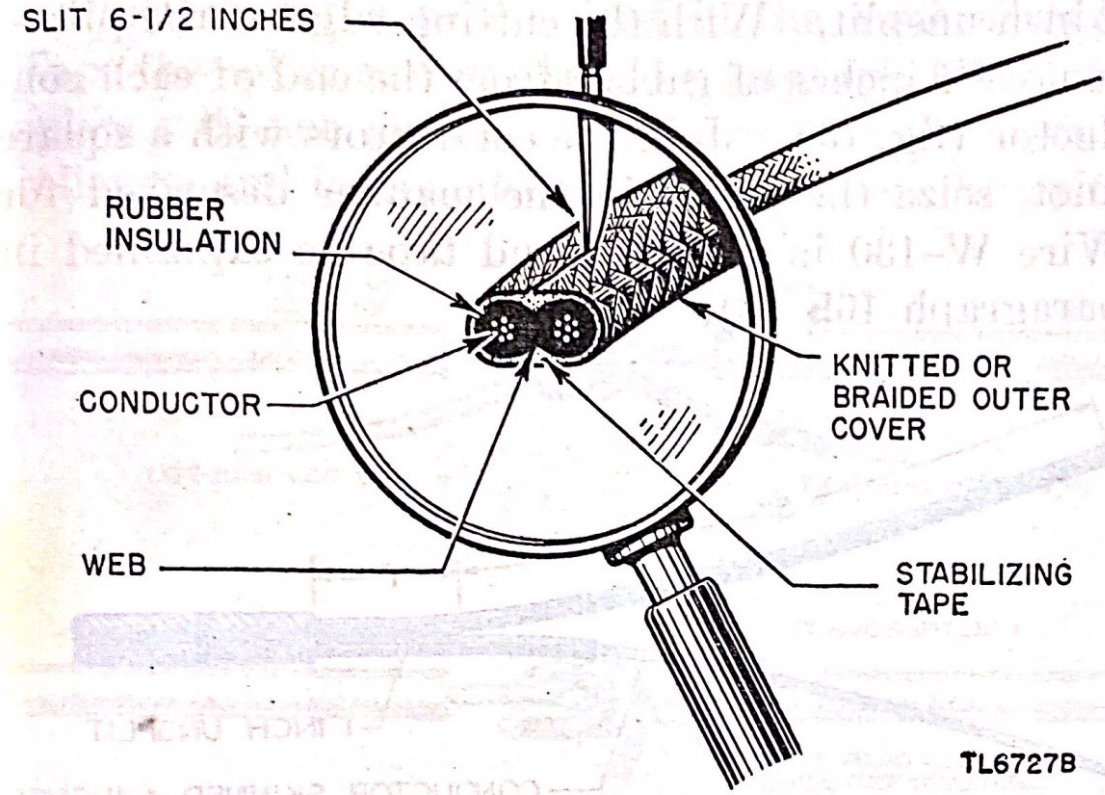


Figure 13. Slitting outer cover of Wire W–143.

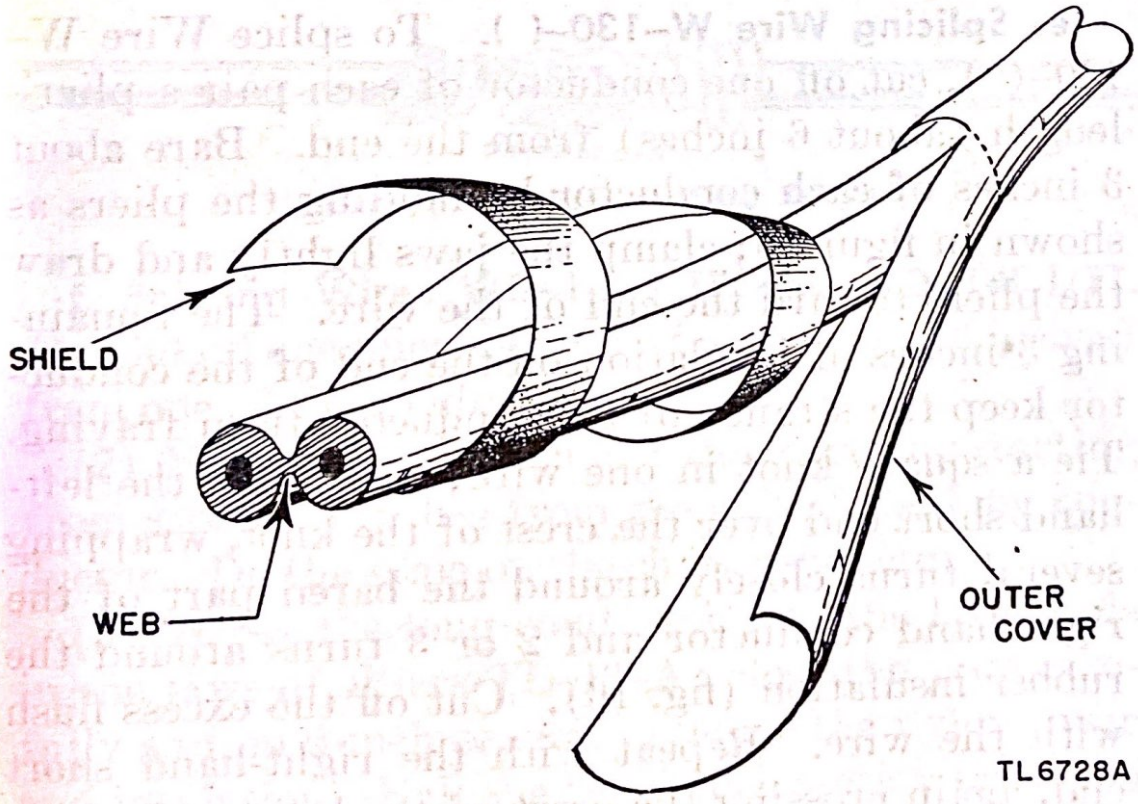


Figure 14. Removing outer cover and shield of Wire W–143.

1 inch unsplit. With the cutting edge of the plie remove 4 inches of rubber from the end of each co ductor (fig. 15). Join the conductors with a squa knot, seize the splice in the manner described f Wire W–130 in **e** below, and tape as explained paragraph 16**b** (2).

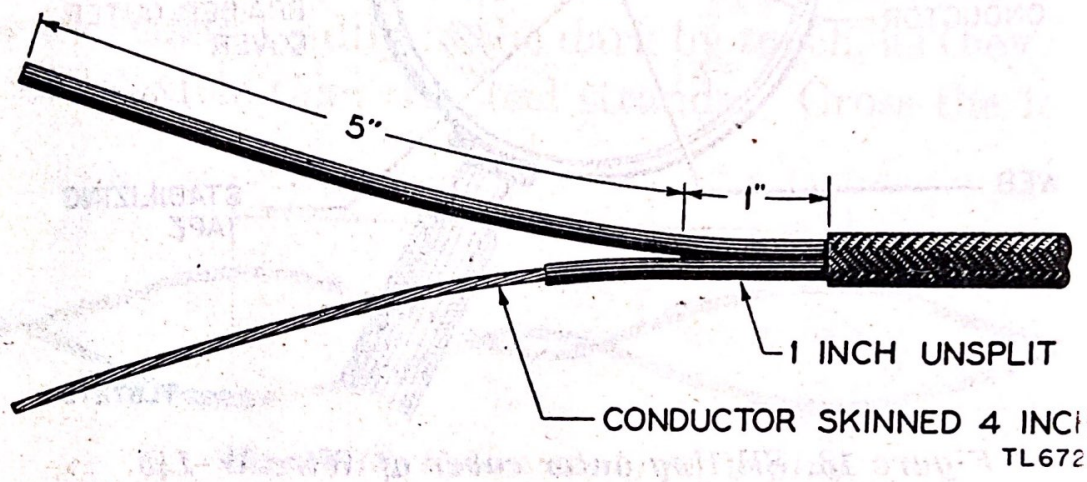


Figure 15. Conductors of Wire W–143 separated, one skinne

e. Splicing Wire W–130–( ). To splice Wire W 130–( ), cut off one conductor of each pair a plier length (about 6 inches) from the end. Bare abou 3 inches of each conductor by holding the pliers a shown in figure 6; clamp the jaws lightly and dra the pliers toward the end of the wire. The remain ing 3 inches of insulation on the end of the condu tor keep the strands of the conductor from frayin Tie a square knot in one wire; then cross the lef hand short end over the crest of the knot, wrappi several turns closely around the bared part of th right-hand conductor and 2 or 3 turns around th rubber insulation (fig. 16). Cut off the excess flus with the wire. Repeat with the right-hand sho end, again crossing the crest of the knot and wra ping around the left-hand conductor. The oth

conductor of the pair is tied in the same manner. Tape the splice as described in paragraph 16**b**. This splice will not loosen when tension on the wire is relieved, and it has adequate electrical conductivity.

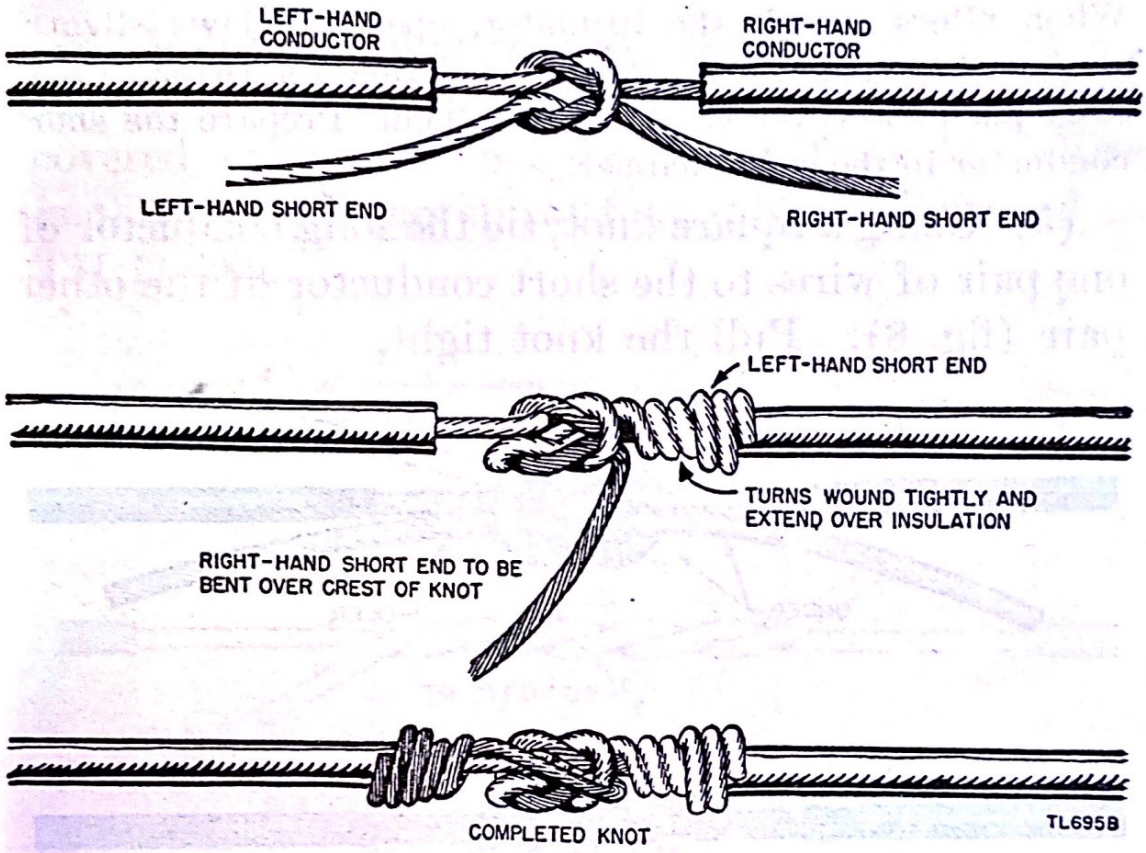


Figure 16. Splicing Wire W–130.

f. Splicing Wires WD–1 ( )/TT and WD–14( )/TT. (1) Cut off one plier's length of wire (about 6 inches) from one of the conductors.

(2) Strip one-half inch of nylon covering starting from a point 6 inches from the end of the long conductor. Do the same on the short conductor.

(3) Insert the long conductor into the large hole in the jaws of Pliers TL–13–A; close the jaws carefully and, in 2-inch sections, remove the nylon cover and insulation. Pull the last 2-inch section up to the end of the conductor to bind the wire strands. Repeat this procedure for the short conductor.

(4) Repeat this procedure for the other pair wires.

Note. On Wire WD–14( )/TT, push back the weatherpro braid cover with pliers TL–13–A to expose one-half inch insulator away from the knot for application of rubber ta When pliers engage the insulator, open the jaws slight so that they clear the insulator but engage the cover. Ca fully push the cover back one-half inch. Prepare the sho conductor in the same manner.

(5) Using a square knot, tie the long conductor o one pair of wires to the short conductor of the oth pair (fig. 8). Pull the knot tight.

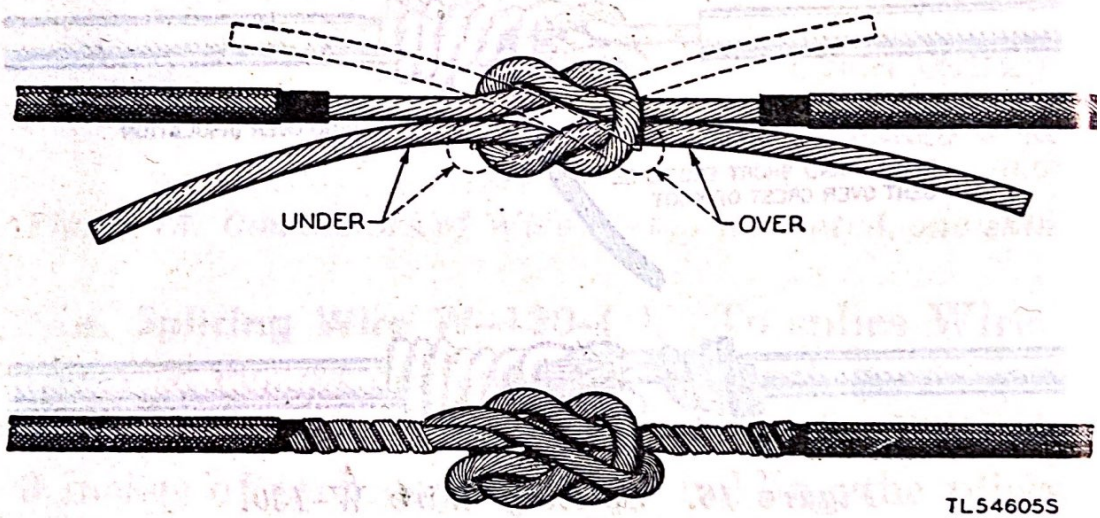


Figure 17. Completed knot in Wire WD–1( )/TT.

(6) Remove surplus insulation from the ends of the conductors. Fan out and bend back the copper strands.

(7) Cut the loose ends of the steel strands flush with the end of the insulator. Cross the left-hand tail end of the copper strands over the crest of the square knot; then wrap several turns closely over the bared portion of the right-hand conductor and the cut-off steel strands. Cut off excess copper strands.

(8) Repeat the seizing with the right-hand tail end, again crossing over the crest of the square knot

and wrapping the tail around the left-hand conductor.

(9) Treat the other conductor in the same manner.

(10) Tape splice as indicated in paragraph 16b(1).

g. Splicing rubber-covered cable. Complete instructions for splicing 5-pair and 10-pair rubber-covered cable are included in TM 11–371. The method of splicing spiral-four cable is discussed in TM 11–369.

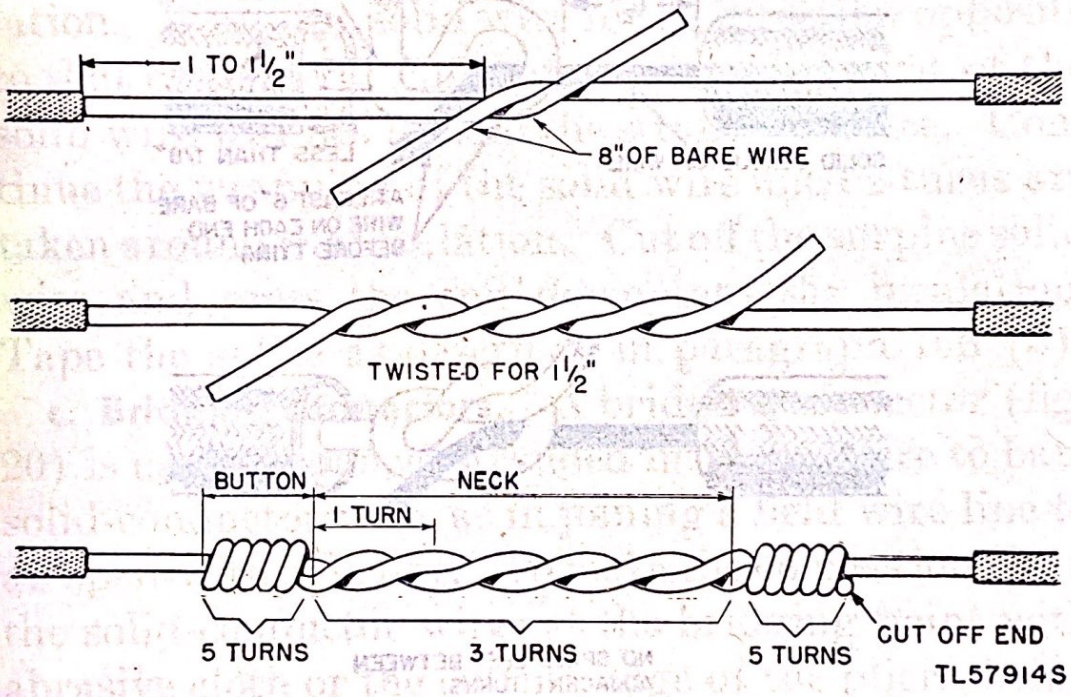


Figure 18. Western Union splice for solid conductors.

15. SPECIAL WIRE SPLICES AND CONNECTIONS. a. Western Union splice. The Western Union splice (fig. 18) is used in splicing two solid-conductor insulated wires, such as Wire W–50. To make the splice, strip the insulation from the end of each wire for a distance of about 8 inches and scrape the wires clean. Twist the bared wires together in the center for a distance of about 1½ inches. Then bend the ends at right angles to the axis of the wire and wrap

each end around the wire for at least 5 close turns. The twisted part of the splice is called the *neck* and the 5 close turns at each end are called the *buttons*. Cut off the ends as close as possible, being careful not to leave a sharp point that will puncture the tape wrapping. See paragraph 16**b**(3) for method of taping this splice.

b. Combination splice. The combination splice (fig. 19) is used to splice a stranded-conductor insu-

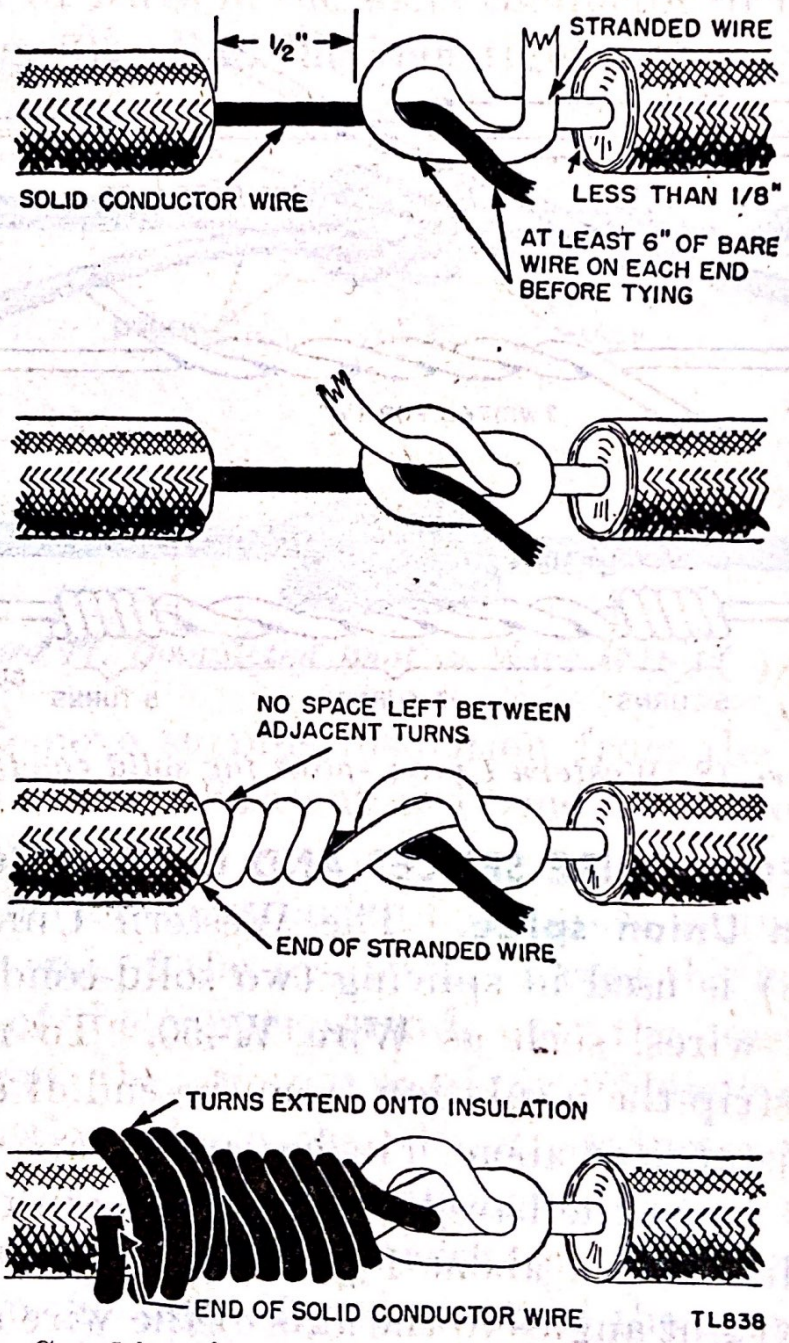

1/2"
STRANDED WIRE
SOLID CONDUCTOR WIRE
LESS THAN 1/8"
AT LEAST 6" OF BARE WIRE ON EACH END BEFORE TYING
NO SPACE LEFT BETWEEN ADJACENT TURNS
END OF STRANDED WIRE
TURNS EXTEND ONTO INSULATION
END OF SOLID CONDUCTOR WIRE
TL838

Figure 19. Combination splice, solid to stranded conductor.

lated wire to a solid-conductor insulated wire. To make the splice, strip the insulation from the end of each wire for a distance of about 6 inches and scrape the wires clean. Tie an overhand knot (first half of a square knot) in the stranded wire about one-eighth inch from the insulation and slip the knotted wire over the solid wire to within one-half inch of the insulation. Cut off the surplus stranded wire. Bend the end of the solid wire back at the knot; with this, seize the stranded wire, wrapping as far as the insulation. Wrap the solid wire in the direction opposite to that of the wrappings of the stranded wire, or the solid wire will fail to hold the strands in place. Continue the wrapping of the solid wire until 2 turns are taken around the insulation. Cut off the surplus solid wire and press the end down into the insulation. Tape the splice as described in paragraph 16**b** (3).

c. Bridging connectors. A bridging connector (fig. 20) is used to connect stranded insulated wire to bare solid-conductor wire, as in joining a field wire line to an open-wire pole line. To make the connection clean the solid-conductor wires at the bridging point with abrasive cloth or the cutting edge of the pliers, being careful not to damage the wires. Place the bridging connectors in position on the solid wires (top wire in fig. 20), and fasten them securely by means of the hexagonal nut. Skin and clean the ends of the insulated wire and wrap the bared ends around the threaded part of the connector between the two washers. Fasten securely by tightening the nut.

d. Combination seizing wire splice. This splice is used to connect an insulated stranded conductor to a bare solid conductor, such as is used on an open wire

pole line when bridging connectors are not available (fig. 21). To make the splice, strip about 1 inch of insulation from the end of the stranded wire and clean both the stranded and bare wires. Lay the bared end of the stranded wire along the solid wire.

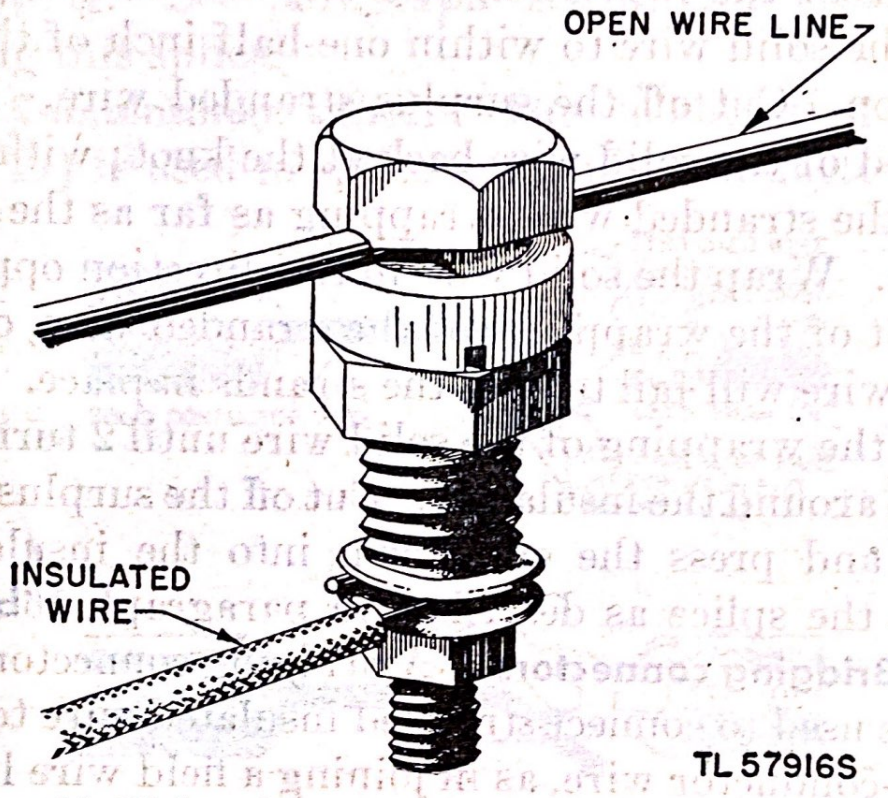


Figure 20. Field wire connected to open wire by bridging connector

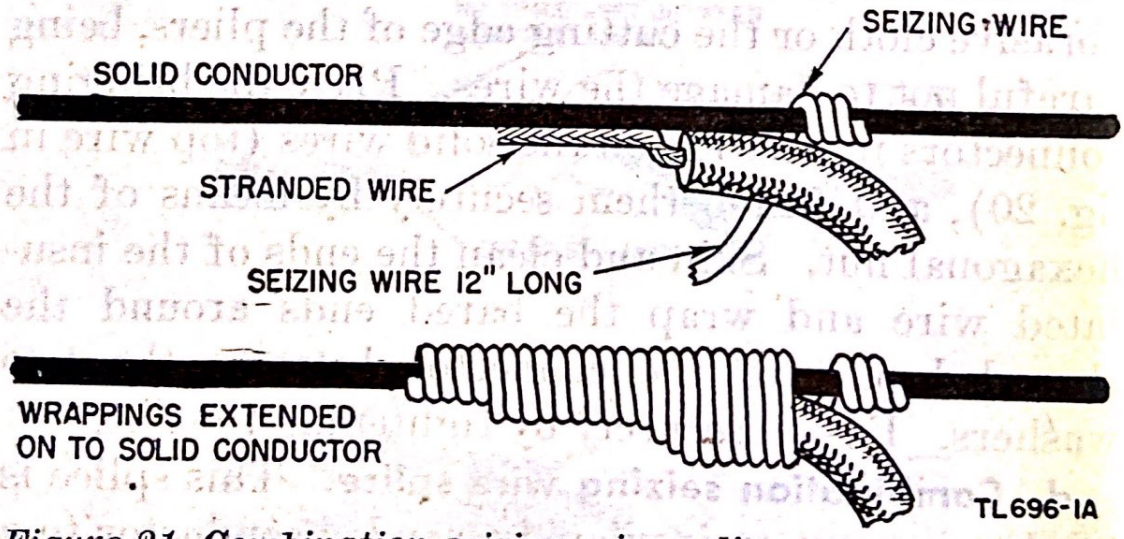


Figure 21. Combination seizing wire splice, stranded to solid conductor

To begin the seizing, take 4 turns with the seizing wire around the solid wire in back of the stranded wire. Continue the wrapping, taking several turns over the insulation of the stranded wire, then over the bare end of the stranded wire, and finally 4 turns over the solid wire. Wrap the seizing wire tightly and draw the turns against each other. Tape the splice as described in parabraph 16**b** (4).

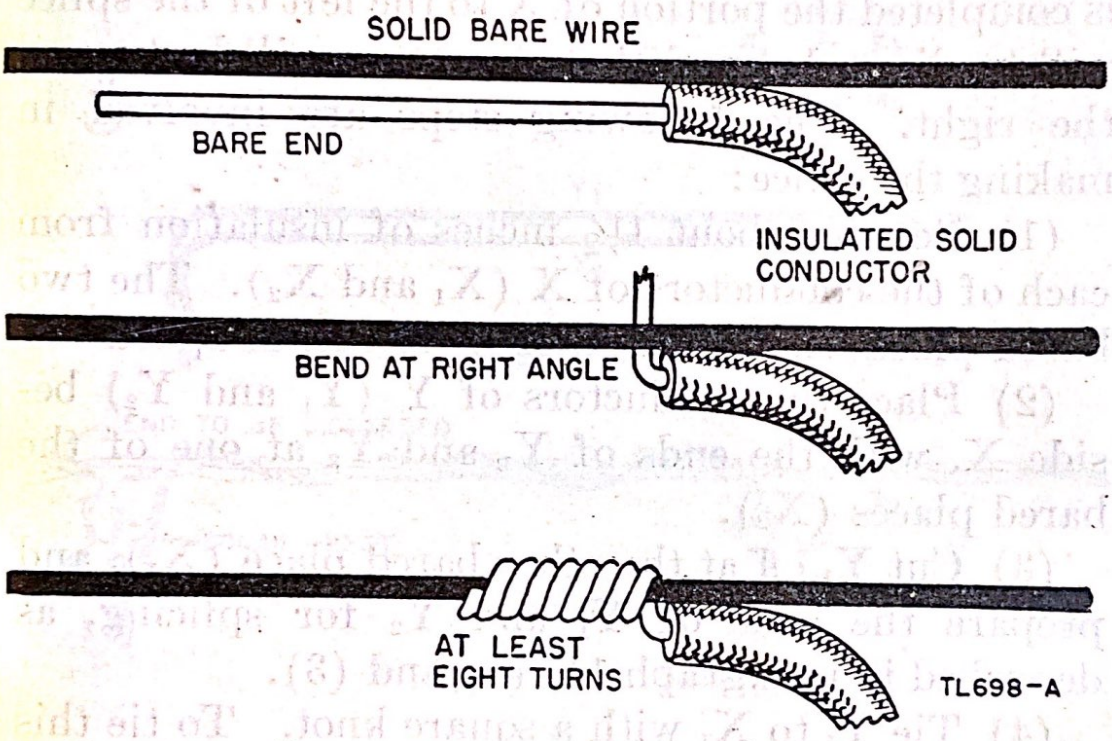


Figure 22. Commercial splice, solid to solid conductor.

e. Commercial splice. The commercial splice (fig. 22) is used to connect an insulated solid conductor and a bare solid conductor, as used on an open-wire pole line, when bridging connectors are not available. To make the splice, remove the insulation from the insulated wire for a distance of about 6 inches and clean both the insulated and bare wires. Lay the bared end of the insulated wire along the bare wire. Bend this end at right angles to the bare wire and wrap it around the bare wire for at least 8 turns,

drawing the turns tight and close together. C
off the surplus end of the insulated wire. See par
graph 16**b** (3) for method of taping the splice.

f. T-splice. The T-splice is used to splice one wi
to another without interrupting the circuit of whi
the latter is a part. In figure 23, X is the wire
the circuit and Y is the wire to be connected.
this illustration it is assumed that after the spli
is completed the portion of X to the left of the spli
will be discarded and that the strain will be towa
the right. The following steps are involved
making the splice:

(1) Remove about 1½ inches of insulation fr
each of the conductors of X (X_1 and X_2). The t
bared places should be 12 or more inches apart.

(2) Place the conductors of Y (Y_1 and Y_2) b
side X, with the ends of Y_1 and Y_2 at one of t
bared places (X_2).

(3) Cut Y_1 off at the other bared place (X_1), a
prepare the ends of Y_1 and Y_2 for splicing,
described in paragraph 14**c** (2) and (3).

(4) Tie Y_1 to X_1 with a square knot. To tie t
knot, make a loop with the left hand in the bar
part of X_1; with the right hand, pass the end
Y_1 up through the loop, over the right side of t
loop, under the neck of the loop, over the left si
of the loop, and down through the loop. Draw t
knot tight. To avoid making a thief or granny kn
be sure that the two conductors on which the str
is to be placed are on the same side of the loo
otherwise the knot will not hold.

(5) Twist Y_2 around X_1 and X_2. Then tie Y_2
X_2, as described in (4) above.

(6) Cut off the portion of X to be discarded and complete the splice as indicated in paragraph 14c.

16. TAPING SPLICES. **a.** The insulation on wire splices is subject to the same electrical and mechanical stresses as the insulation on the wire itself. Therefore, it is important that a wire splice be taped ade-

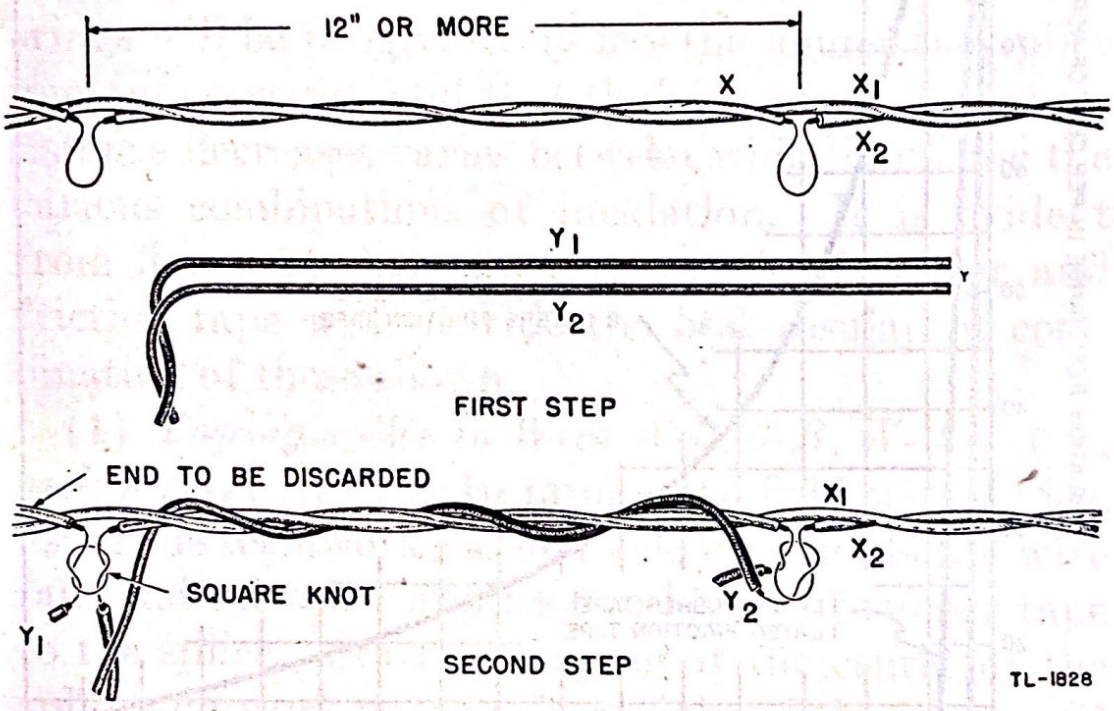


Figure 23. T-splice

quately to insure good mechanical protection and high insulation resistance. To accomplish this, tape the splice, overlapping each turn with both rubber and friction tape. The rubber tape makes the splice as nearly watertight as possible, whereas the friction tape protects the rubber tape against abrasion, deterioration from sunlight, or other weather conditions.

b. Figure 24 shows the relative effectiveness of combinations of rubber and friction tape for insulating field wire splices. In this graph, the insulation

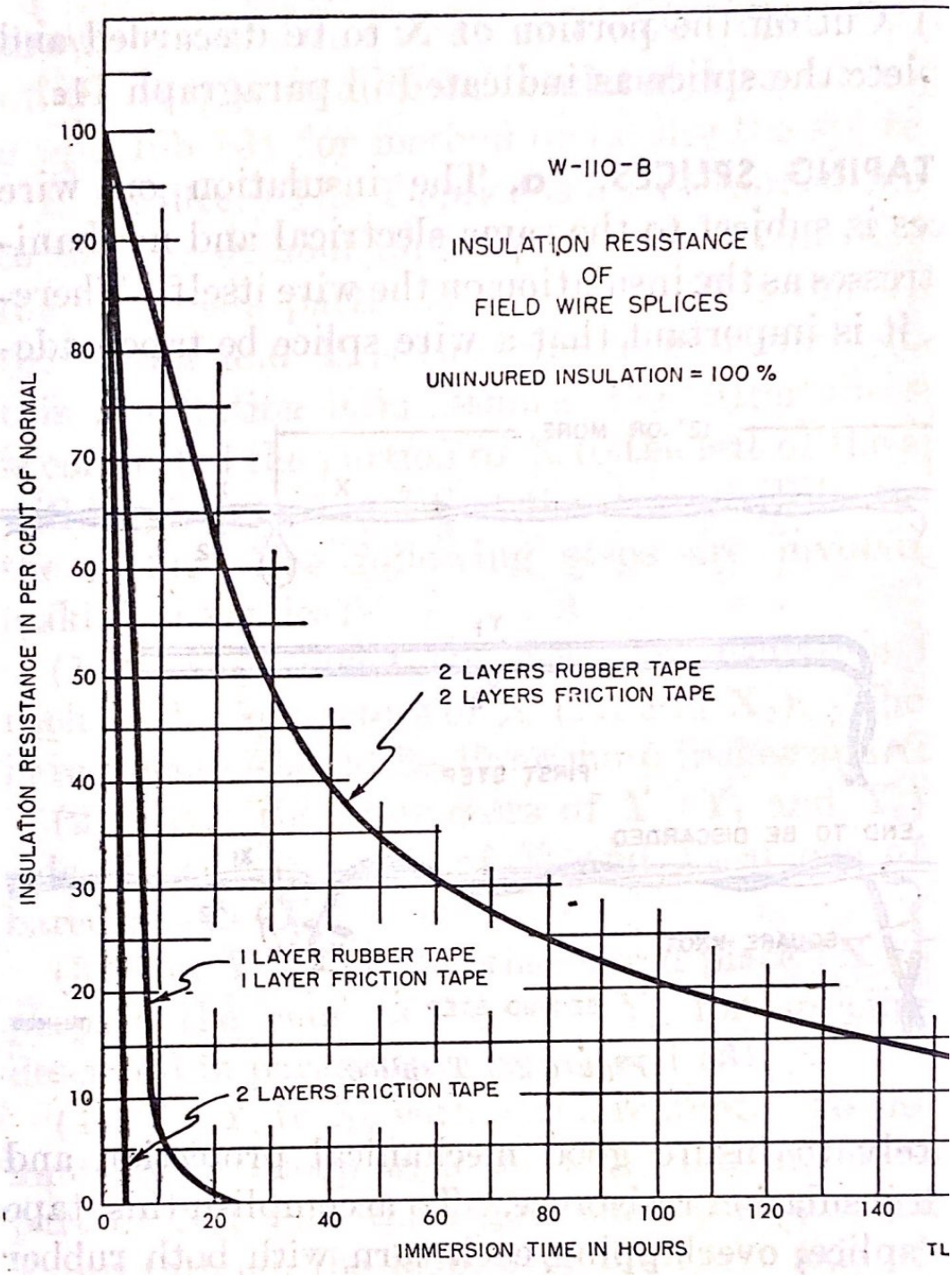


Figure 24. Insulation resistance of field wire splices.

resistance of new wire is taken as the standard reference and evaluated at 100 percent. The verti scale represents the ratio, in percent, of the act insulation resistance of the given splice covering the standard insulation resistance of the uninju new wire. The horizontal scale gives the immers

time of the splices in water. The curves indicate the percentage of normal insulation resistance during successive hours of immersion. The curves shown are not correct necessarily for all taped splices, as the quality of the tape used, as well as the care with which the tape is applied to the splice, will affect the comparison. The curves in figure 24, however, do show correctly that the insulation resistance of splice coverings will be progressively less the longer the splice remains in water, and that the rate at which the resistance decreases varies between wide limits for the various combinations of insulation. It is evident from figure 24 that two layers each of rubber and friction tape will provide the best insulation combination of those shown.

(1) *Taping splice in Wire W–110–B, W–130–( ), and WD–1( )/TT.* In taping the field wire splice, using the teamwork method, one man holds the wire taut and the other applies two layers of rubber tape to the splice. Start the taping at the center of the splice and work to the left or right of the knot until one-half inch of the rubber insulation on the conductor has been covered. Work the tape back again over the knot until one-half inch of rubber tape covers the rubber insulation at the other side, and finally back again so that it ends at the center of the splice (fig. 25). Stretch the rubber tape considerably during winding in order to give close adhesion; then press it against the rubber insulation on both ends of the splice to make the splice waterproof. Wrap two layers of friction tape in the same manner over the rubber tape. Extend the friction tape about 1 inch beyond the rubber tape (fig. 26) and then roll it sev-

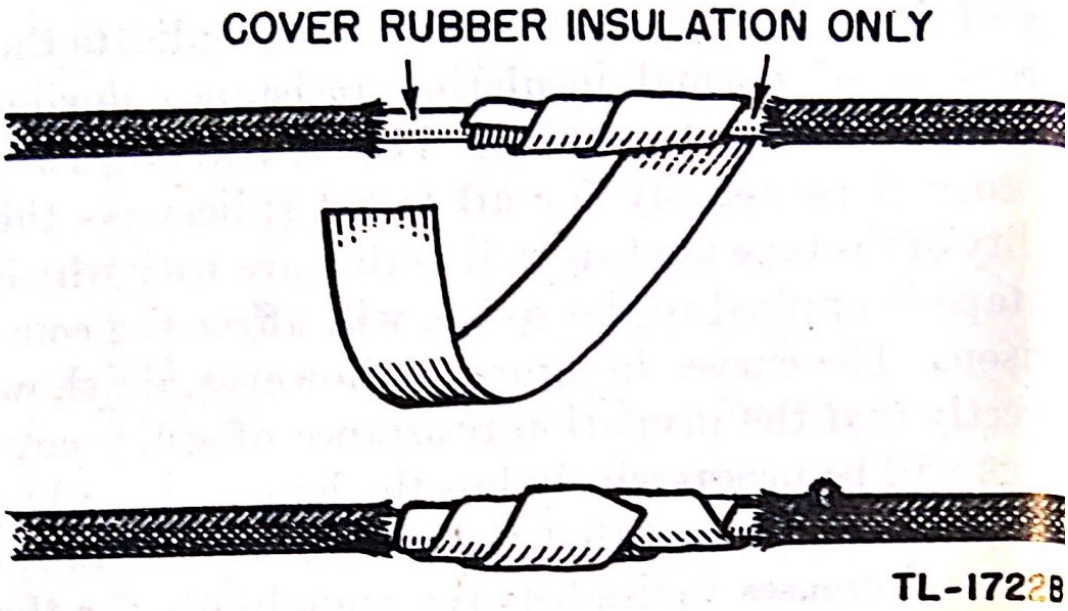


Figure 25. Applying rubber tape.

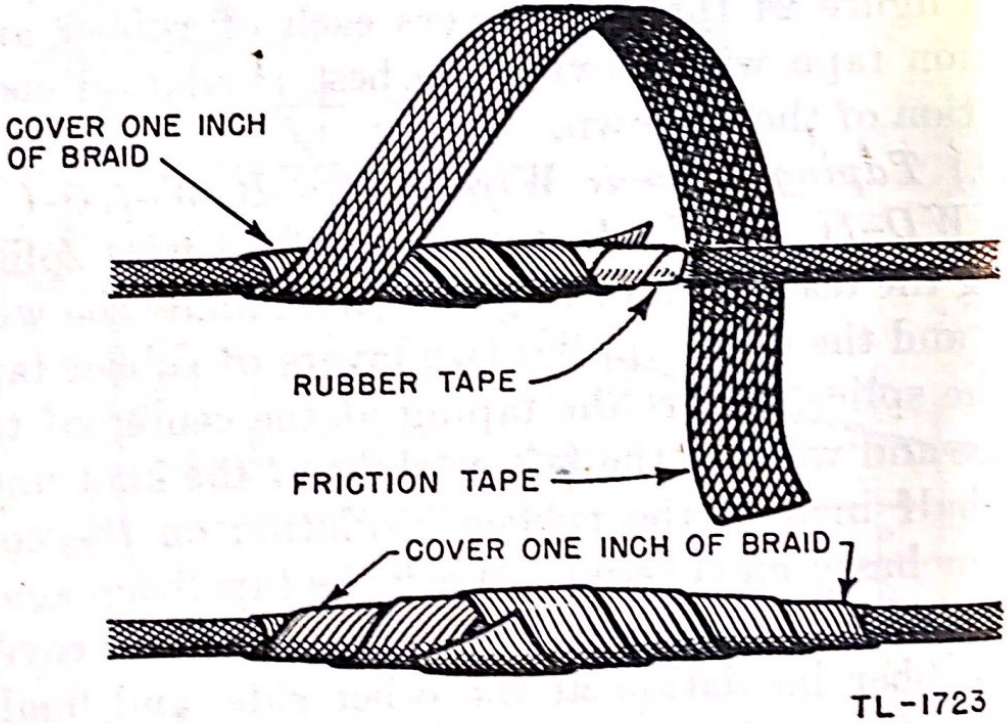


Figure 26. Applying friction tape.

eral times in the hands to seal the edges of the tap This results in an over-all taped splice of about inches on each wire of the pair.

(2) *Taping splice in Wire W–143.* Apply tw layers of rubber tape to each splice, as described fo Wire W–110–B. Then, at a point 1 inch from th

crotch of the splice, start wrapping a 4-inch piece of rubber tape and make 2 tight turns around the nearest wire (fig. 27①). Next make 2 tight turns around the unsplit portion of the pair. Bring the tape over the crotch, spacing it evenly so that it covers each side of the crotch as shown in figure 27②. Then make 1 close turn to cover the crotch lap on the opposite wire and 2 additional turns around the wire to complete the operation (fig. 27③). When the rubber taping is completed, apply two layers of friction tape over the two conductors. Start this taping

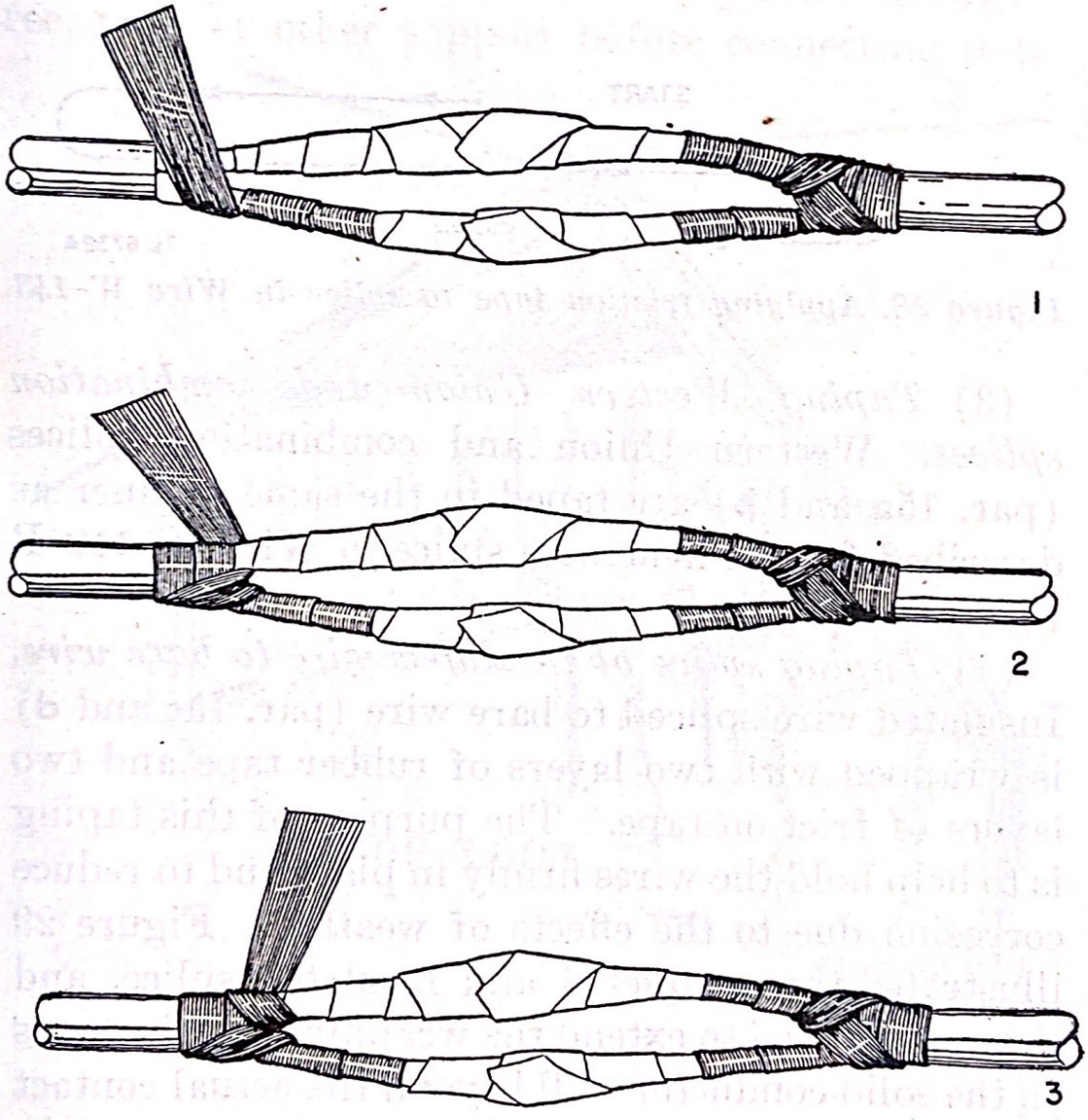


Figure 27. Applying rubber tape to splice in Wire W–143.

at the center of the splice and work to right or le
for a distance of 1 inch on the outer braid; the
bring the tape back to the other end, extend it ov
the braid for 1 inch, and finish in the center (fig. 28
Roll the completed splice between the hands to obta
good adhesion.

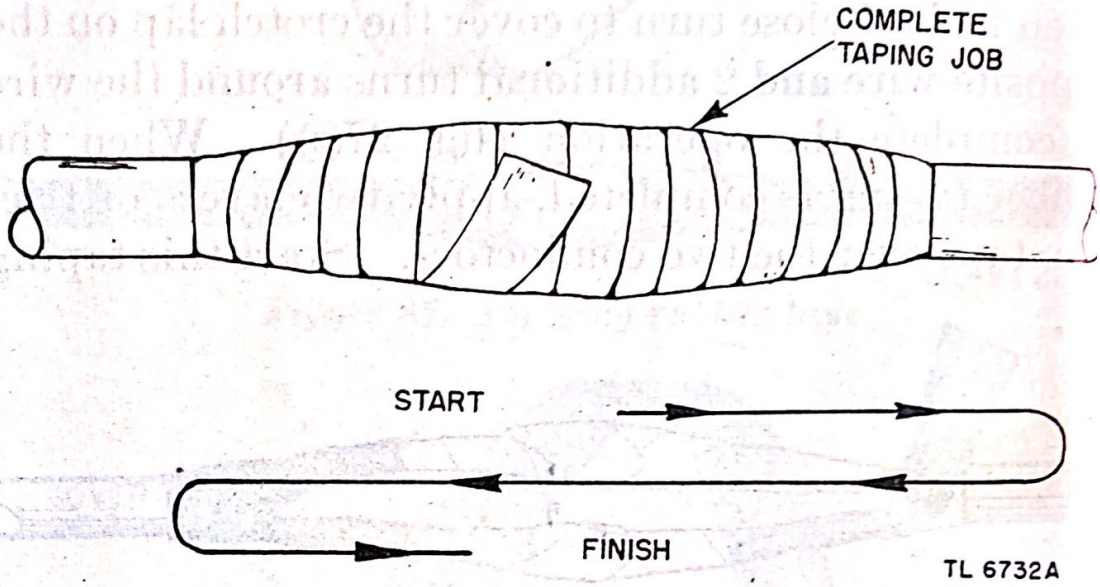


Figure 28. Applying friction tape to splice in Wire W–1

(3) *Taping Western Union and combinatio splices.* Western Union and combination splice (par. 15**a** and **b**) are taped in the same manner a described for the field wire splice in Wire W–110–H ((1) above).

(4) *Taping splice of insulated wire to bare wir* Insulated wire spliced to bare wire (par. 15**c** and **d** is wrapped with two layers of rubber tape and tw layers of friction tape. The purpose of this tapin is to help hold the wires firmly in place and to reduc corrosion due to the effects of weather. Figure 2 illustrates the completed and insulated splice, an the method used to extend the wrappings of the tape on the solid conductor well beyond the actual contac region of the two conductors.

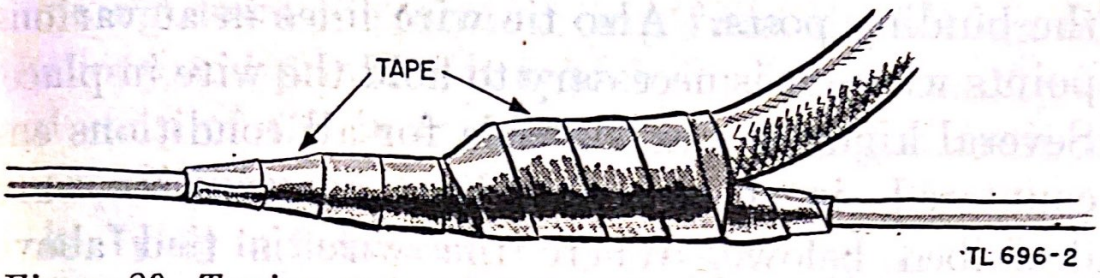


Figure 29. Taping an insulated conductor spliced to bare wire.

17. WIRE TIES. a. General. Field wire lines usually terminate at the binding posts of a terminal strip or an instrument, and any strain placed on the wire tends to pull the wire away from the binding posts. To avoid this, fasten the wire securely to a convenient tree, pole, or other support before connecting it to

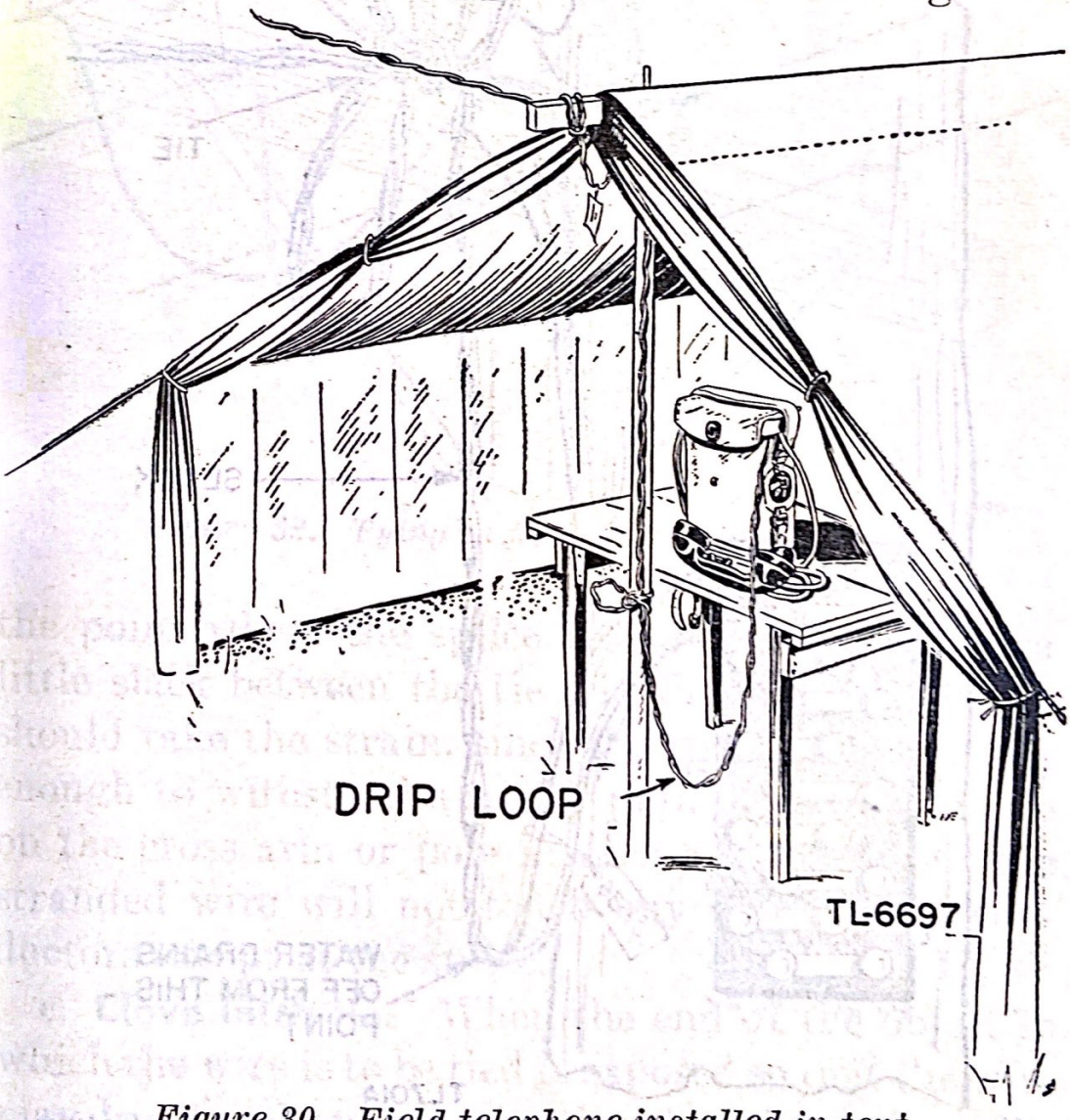


Figure 30. Field telephone installed in tent.

the binding posts. Also tie wire lines in at var
points where it is necessary to hold the wire in p
Several kinds of ties, suitable for all conditions
countered in field wire line construction,
described below. Where the wire is tied a
equipment to which it is to be connected, such
telephone or terminal strip, a drip loop (figs. 30
31) is made in the wire. The drip loop allows w

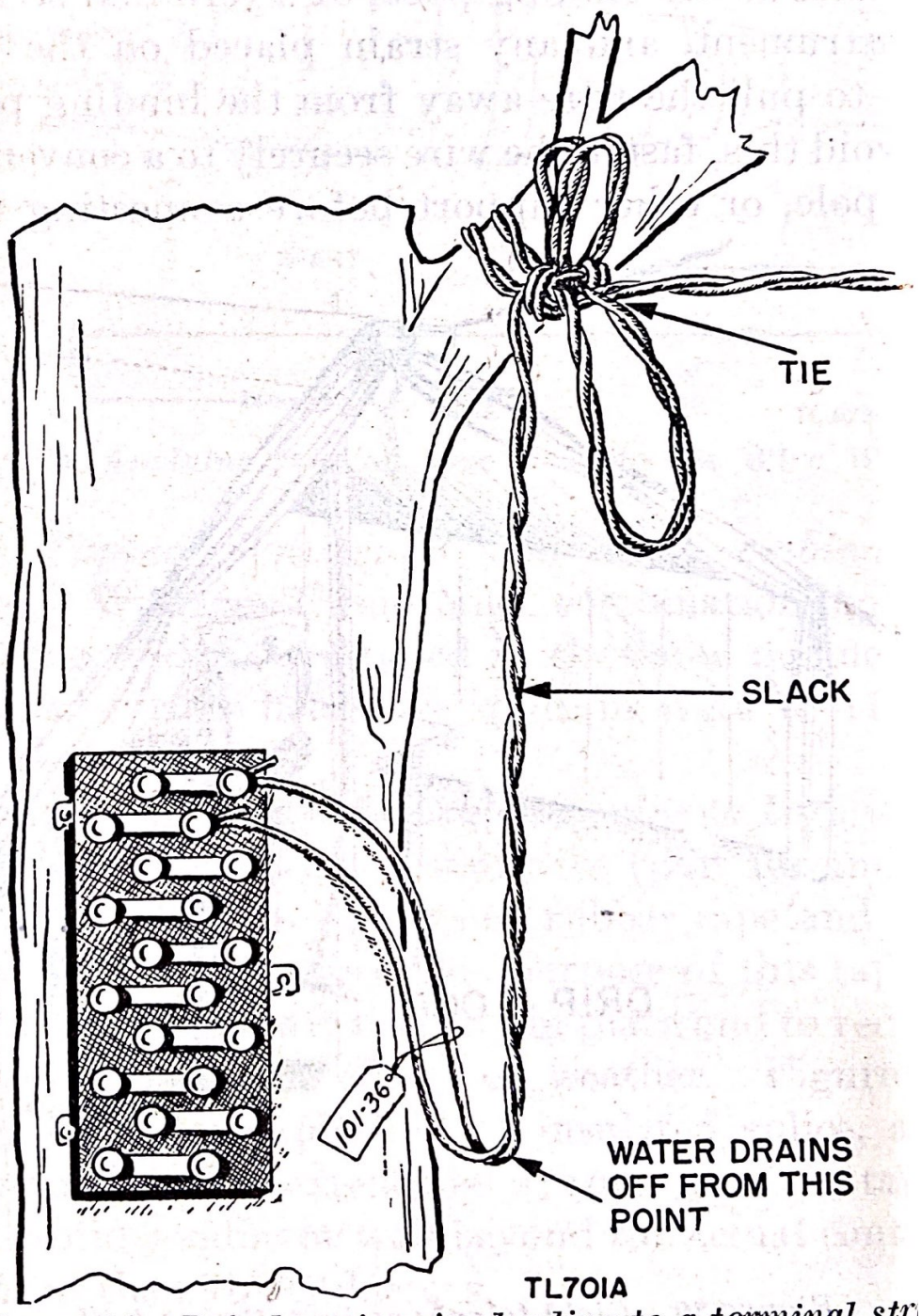


Figure 31. Drip loop in wire leading to a terminal str

running down the wire to drip from the bottom of the loop and prevents it from being led to the terminal strip of the instrument where it might cause a short circuit or damage the equipment.

b. Tying in field wire to open wire (fig. 32). Normally, stranded wire is connected to solid conductor wire only where it is necessary to connect a field wire to an open-wire line. Tie the stranded wire to the cross-arm or pole (but never to the metal brace) near

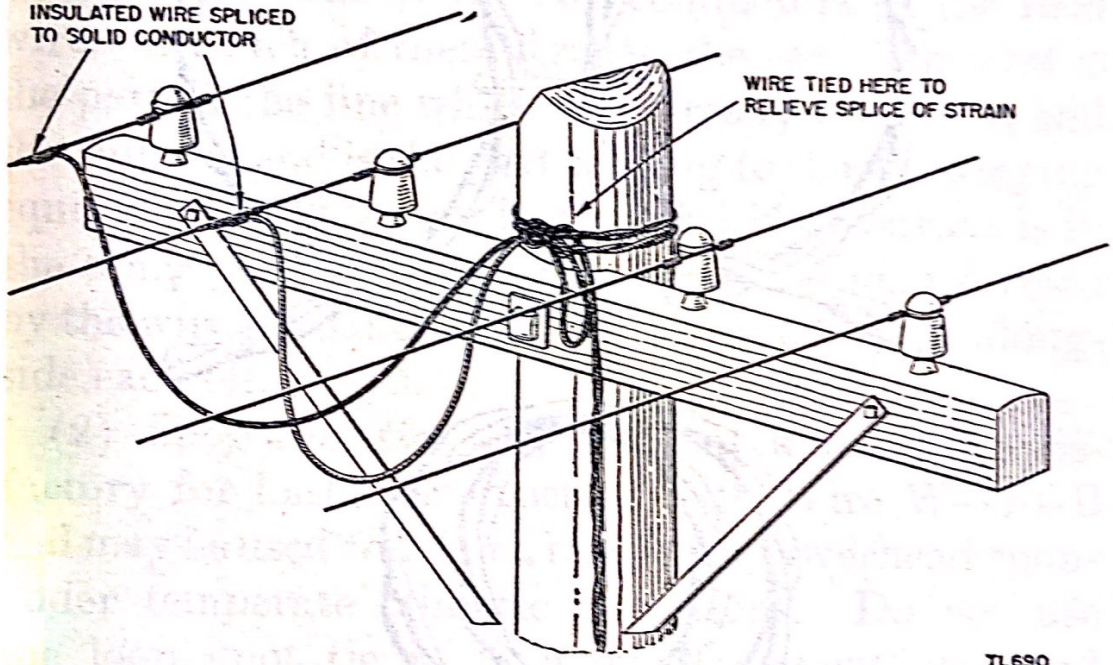


Figure 32. Tying in field wire to open wire.

the point where the splice is to be made. Leave a little slack between the tie and the splice. The tie should take the strain, since the splice is not strong enough to withstand a heavy pull. Position the tie on the cross arm or pole in such a manner that the stranded wire will not touch any of the solid conductors except at the splice.

c. Clove hitch tie. When the end of the object to which the wire is to be tied is exposed so that the wire may be placed over it, use the clove hitch tie. To

make this tie, take two loops in the wire
33 ①). Place the right-hand loop on top of the
hand loop without turning either loop (fig. 33
Place both loops over the object to which the tie
be made and pull them tight (fig. 33 ③).

d. Other knot ties. (1) *General.* When the
of the object to which the wire is to be tied is no

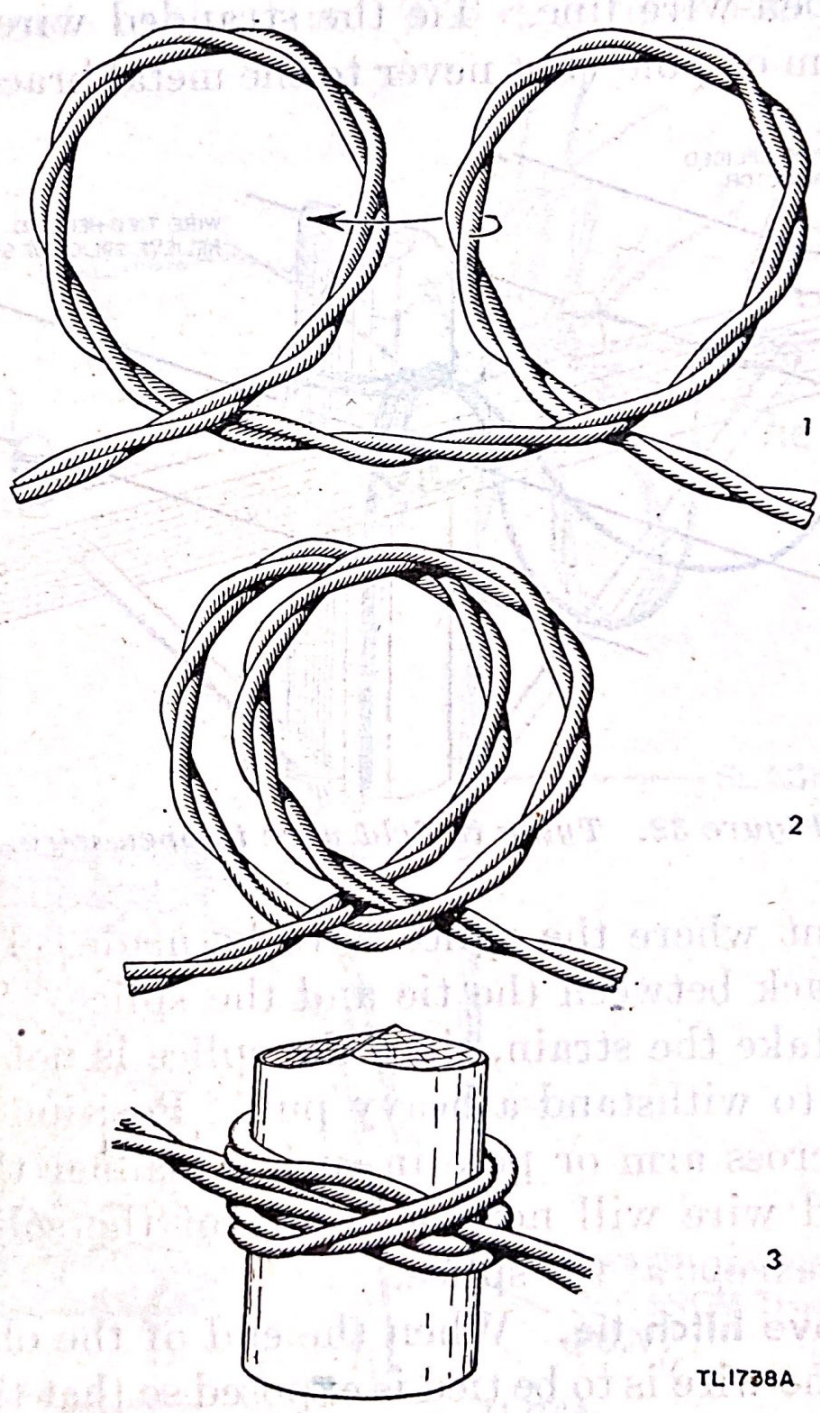


Figure 33. Clove hitch tie around a stake.

posed, use one of the three ties described below. Generally these ties are not suitable for overhead construction because they increase the physical length of the line and, when under tension, increase the probability of electrical trouble. Therefore, other ties (such as the basket hitch or marline tie) should be used for overhead construction whenever possible. All three of the following ties permit tying the wire without cutting it. For simplicity, figures 34 and 35 show only one of the two conductors of the field wire. In each of these figures, the *standing part* is the part of the line which has already been laid, and the running end is the part leading to the wire-laying equipment. This may be reversed if the strain is in the other direction. A *wire bight* is a loop formed by the wire so that the two parts of the loop lie alongside each other.

(2) *Loop knot tie.* (*a*) The loop knot tie is satisfactory for hasty construction with Wire W–110–B and may be used for short, temporary, overhead spans under temperate climatic conditions. Do not use the loop knot tie in long or permanent overhead spans; nor where it may become untied accidentally by passing personnel, vehicles, or animals.

(*b*) To make the loop knot tie stand facing the object on the side on which the wire is being laid. Pull in enough slack to make a bight to go around the object with about 2 feet of bight left over. If, during the tying operation, the greater strain is on the standing part, place the bight around the object in the direction of the running end and continue around to the front on the side toward the standing end (fig. 34 ①). (If the greater strain is on the running end,

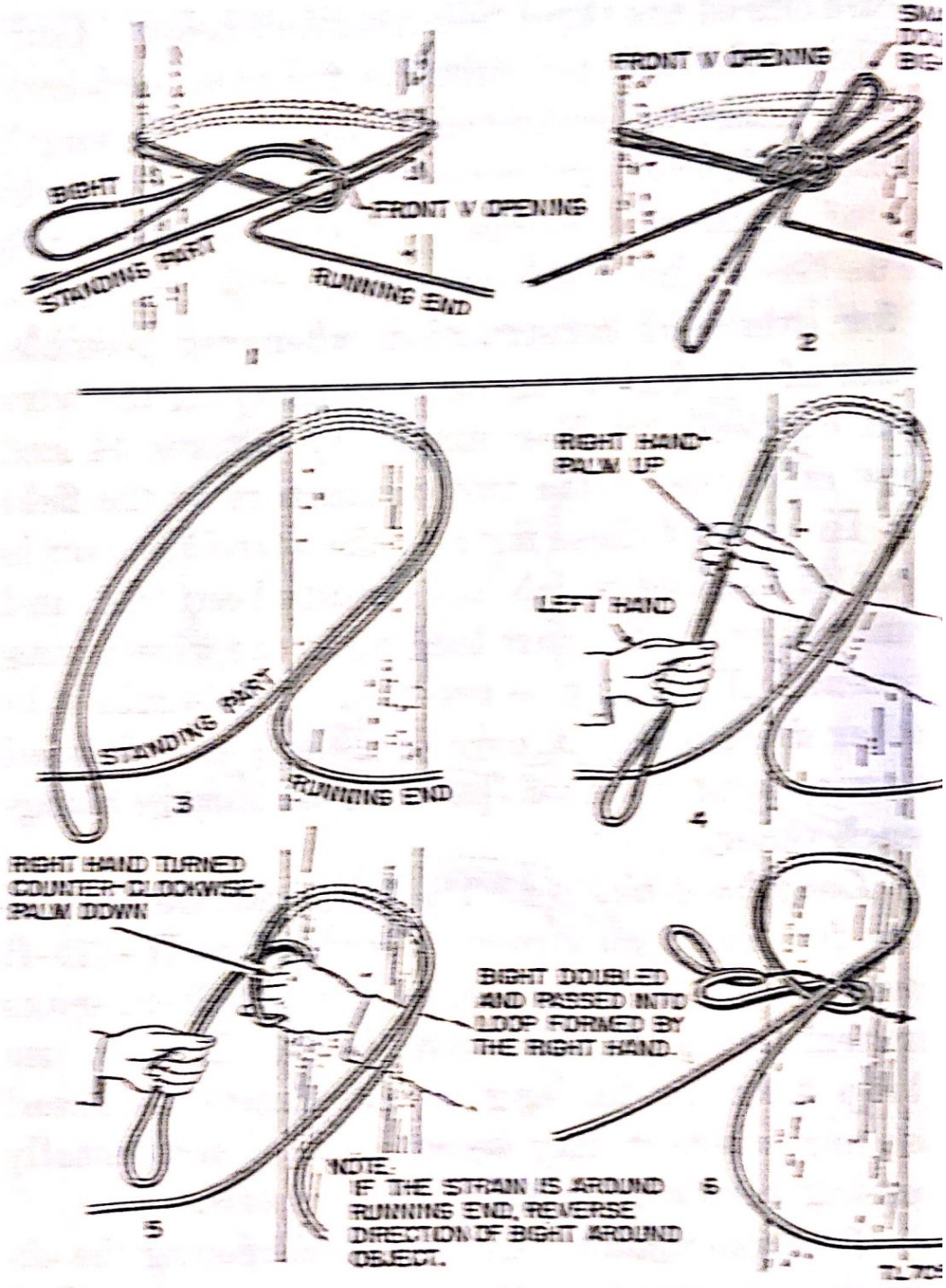


Figure 34. Loop knot ties, showing only one of the tw conductors

place the bight around the object in the oppo direction.) Bring the bight under and then both the standing part and the running end, form the front V-opening shown in figure 34 ①. Re through this opening and pull through it abo

inches of the doubled bight, as shown in figure 34 ②. Tighten the tie, making sure that it rests against the object.

(*c*) An alternate method of making a satisfactory loop knot tie is as follows: After placing the bight around the object (fig. 34 ③), hold the bight in the left hand, pass the right hand under the standing part and running end, then grasp the bight, holding the right hand palm up (fig. 34 ④). Turn the hand in a counterclockwise direction, pulling the loop under the standing part and running end (fig. 34 ⑤). Double the bight and pass it over the line and into the loop, pulling the bight until the knob is tight and against the object (fig. 34 ⑥). To untie pull the free end of the bight through the opening. The wire will fall away from the object.

(3) *Square knot and loop tie.* (*a*) This tie is more secure than the loop knot tie. However, it is not suitable for all field conditions. Do not use the square knot and loop tie in extreme heat or for installations that are expected to remain in use for a long time.

(*b*) To make the tie, begin as in the case of the loop knot tie but bring the bight over both the standing part and the running end and then between the object and the wire (fig. 35 ①). Draw the knot tightly against the object. Bring the bight over the running end, forming the opening (fig. 35 ②). Reach through this opening and pull about 6 inches of the doubled bight through (fig 35 ③). Tighten the tie by holding the doubled bight in one hand and pulling the running end with the other. To untie, pull the free end of the bight through the opening and then untie the bight from the object.

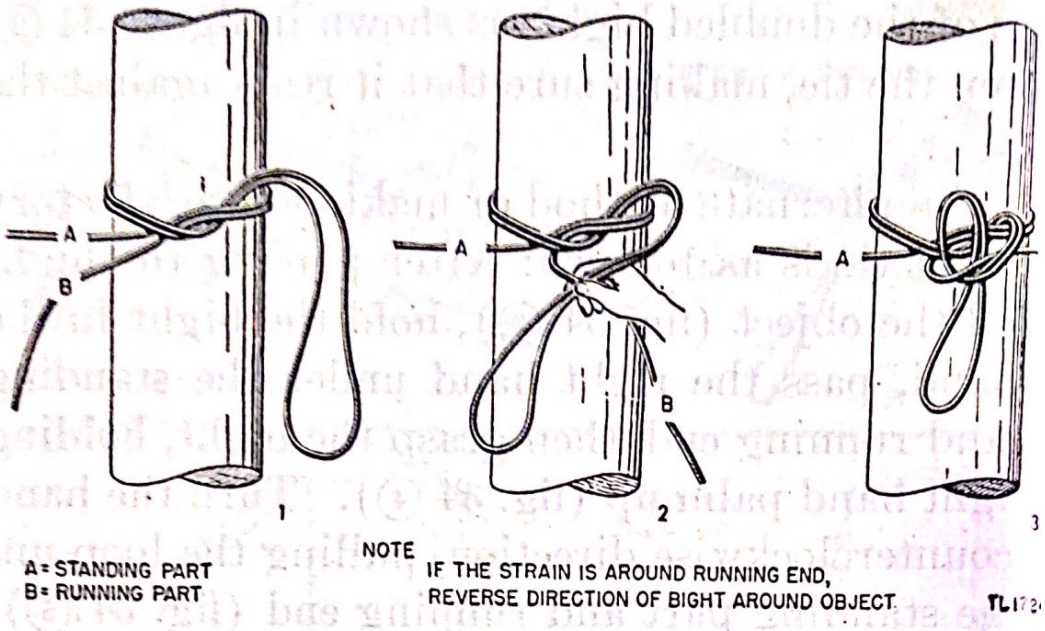


Figure 35. Square knot and loop tie, showing only one of two conductors.

(4) *Square knot tie.* (*a*) This tie, although m secure than those described in (2) and (3) above subject to the same limitations regarding clima conditions and overhead spans.

(*b*) To make the square knot tie, proceed as w the square knot and loop tie, but pull the end of t bight through the opening and tighten it by holdi the end of the bight in one hand and pulling the ru ning end with the other (fig. 34). To untie, reve the above procedure.

e. Knob tie. The knob tie (fig. 36) is used in tyi field wire to a knob or insulator. It is not suitab for tying over larger objects. To make the knob t proceed as follows: form a loop in the wire, separa the two conductors in the loop, bend each conduct back around its side of the length of wire so th they again touch each other at a point 180° from t original position of the loop. Place the loop ov the knob and draw it tight. This tie will not

ectrically satisfactory in extreme heat after 90 days nd is not satisfactory for long spans.

f. Marline tie. The marline tie may be used to ıpport a field wire line on a knob, cross arm, or other ıpport when there is a possibility that the support ı question may damage the insulation of the wire. 'o make the marline tie, take a piece of marline hich, when doubled, will reach from the wire in its ıspended position, pass it twice around the support,

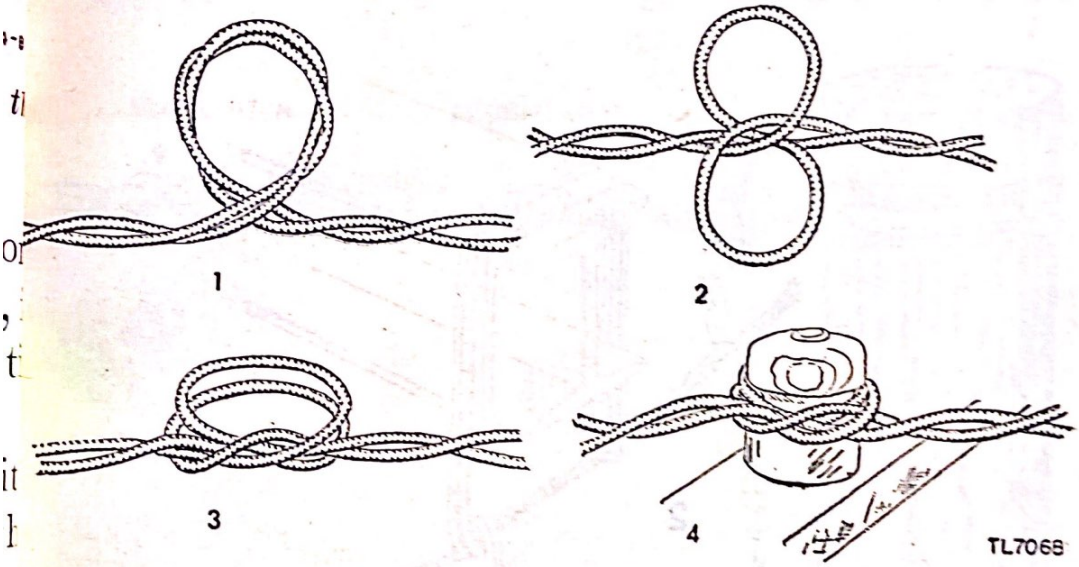


Figure 36. Knob tie.

nd down to the wire again, with about 4 inches left ver for tying. Insert the ends through the loop ormed in the middle of the marline and draw the harline tight around the wire as shown in figure 37 ①. Pass the doubled marline twice around the sup- ort and back to the wire as shown in figure 37 ②. Tie the marline securely to the wire with a clove itch knot. To tie this knot, place the marline round the wire and pass the running ends over the tanding part to form a loop. Then pass the run- ing ends down through this loop as shown in figure 7 ③. Draw the knot tight.

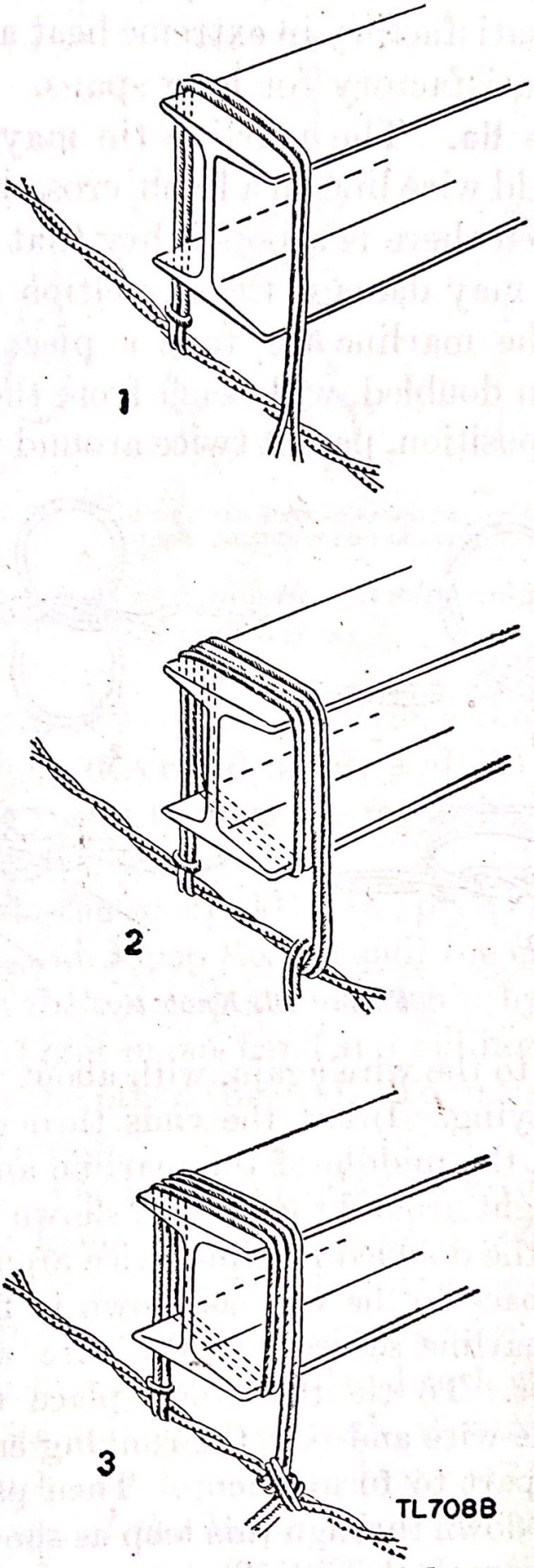


Figure 37. Marline tie to a metal support.

g. Basket hitch tie. Use the basket hitch tie as an ərial tie for Wire W–110–B under conditions of ex-ˈeme heat, long spans, heavy wind, or sleet loading. ˈse the basket hitch tie in all climates to tie Wire ˈ–143 on aerial fixtures, to a stake, or to other ground ıpport. To make the basket hitch tie, take a single ɔnductor of scrap Wire W–110–B, about 10 to 12 ɛet long, and make a clove hitch around the wires ɛing supported. Weave the tie wire around the wire ɔ be supported (fig. 38) being careful to have one

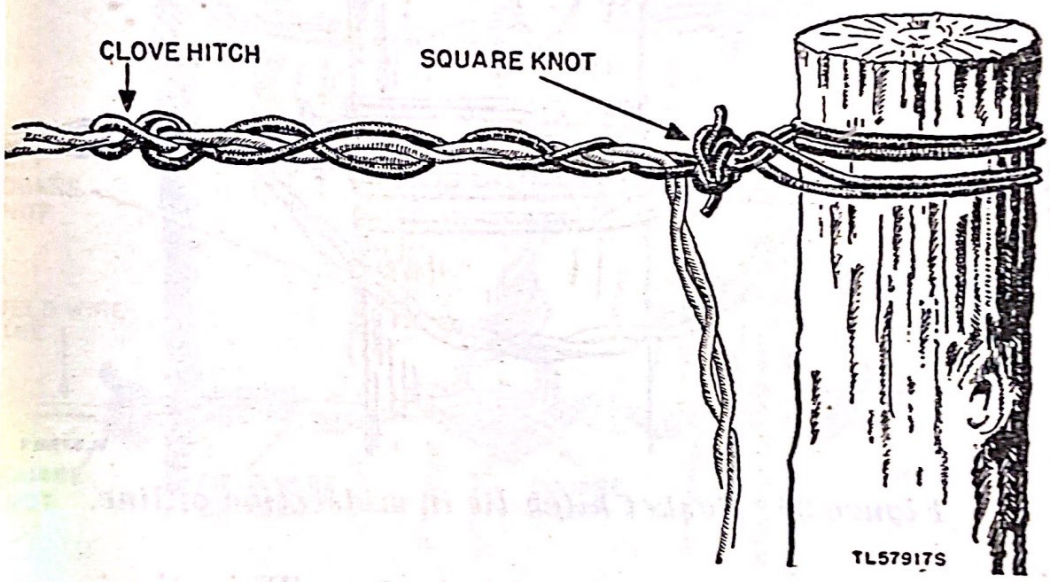


Figure 38. Basket hitch tie.

ɔortion of the tie wire on the inside of one cross and ɔn the outside of the next cross. When the wires are ied in this manner, the gripping action will be evenly listributed for the entire length of the tie. Usually even cross-overs will be sufficient to hold the sup-ɔorted wire. To complete the basket hitch tie, hold he two tie wire ends together and make 1½ turns ɹround the support. Separate the two ends and ake them around the standing part of the tie wire n opposite directions. Tie the two ends together

with a square knot and cut off all excess wire
the supporting structure is in midsection, the
should loop around the pole or tree in such a ma
that it will not come in contact with the support
39). Practice will indicate the proper spacing
tween the two ties.

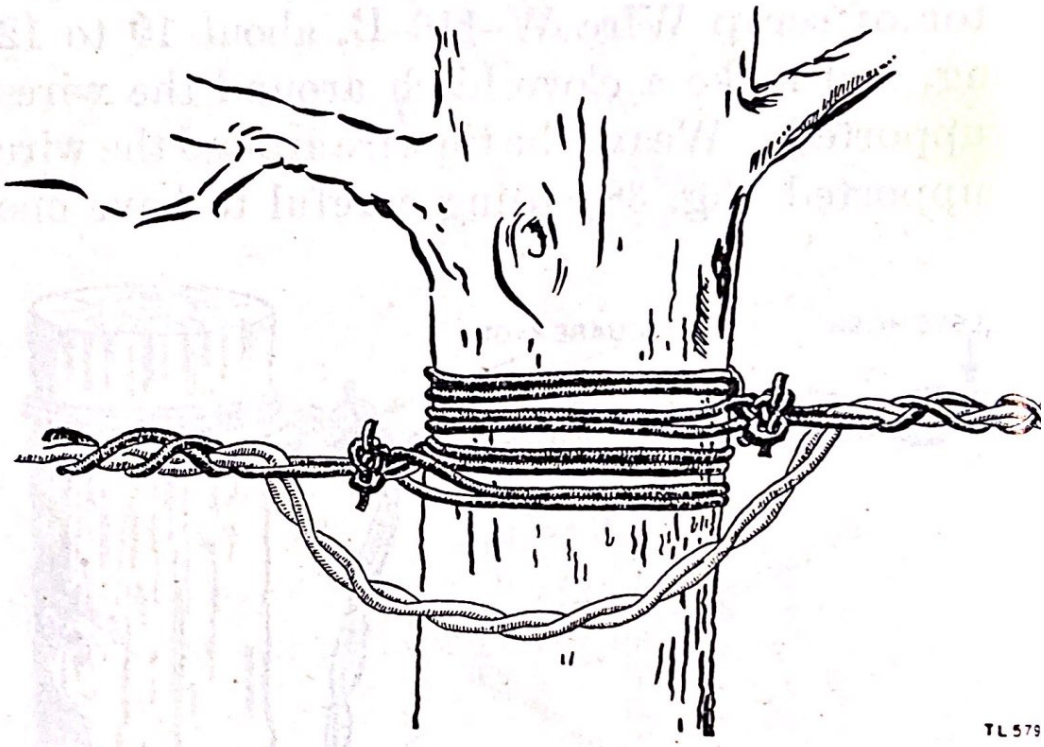


Figure 39. Basket hitch tie in midsection of line.

h. Variation of basket hitch tie. This tie is
suited for use in jungles since the wire line itself
tains no knots. The method of suspension allows
considerable swaying of the tree or other supp
without placing an increased strain on the wire. T
type of tie allows suspension from a horizonta
vertical support and is the same whether the ti
in midsection or at the first or last pole. This tie
disadvantages in that it is slow to make, it mus
made at the point of suspension, and it cannot
started on the ground as is the case with the nor
basket tie. To make the tie (fig. 40), loop a p

of scrap wire (W–110–B) twice around the tree or other point of support and tie a square knot, leaving the free ends of the tie wire 2 or 3 feet long. Twist these ends together into a double twisted pair for about 6 inches and tie an overhand knot (first half of a square knot) ; insert the line to be suspended be-

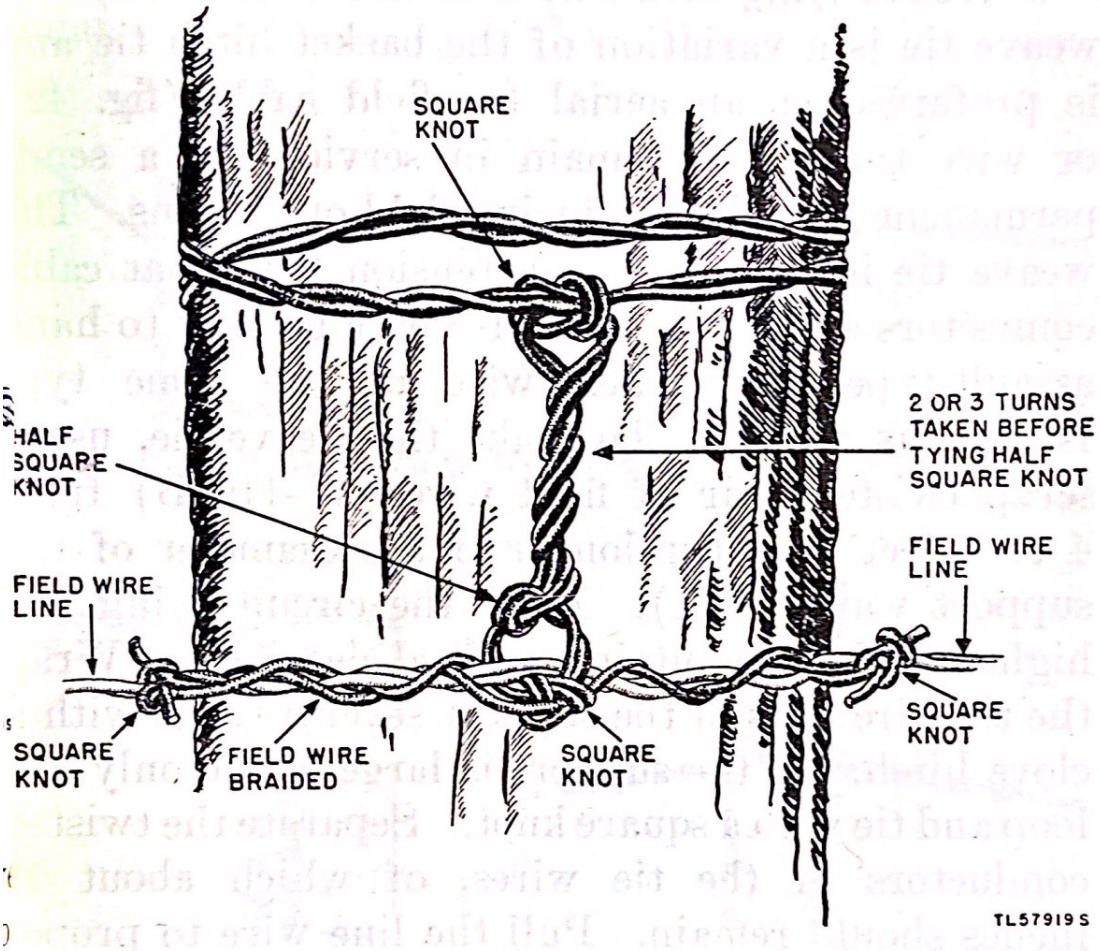


Figure 40. Variation of basket hitch tie.

tween all two pairs of tie wires and tie a square knot. Untwist the remaining ends of the two pairs of tie wires and wind each pair in opposite directions along the wire to be suspended. This is done in the same manner as the basket hitch tie described in **g** above. Be careful to have each strand of the tie wire on the outside of one cross and the inside of the next as in the baset hitch tie. After four or five cross-

overs, tie the ends of each pair of tie wires in a sq
knot and cut off the excess wire.

Note. This tie ends in square knots on the line
whereas the basket hitch tie ends with the square
against the support.

i. Weave tying field wire and field cable. (1)
weave tie is a variation of the basket hitch tie
is preferred as an aerial for field cable (fig.
or wire that is to remain in service for a s
permanent installation during field operations.
weave tie is also used as a tension bridge at c
connectors and splices. It also may be used to h
assault-type wire when wire of the same t
is used as the tie. To make the weave tie, us
scrap twisted pair of field wire (W–110–B) fi
4 to 8 feet long (or longer if the diameter of
support warrants it). Place the circuit being
high enough to maintain standard clearances. W
the tie wire around the support several times wit
clove hitch. If the support is large, make only
loop and tie with a square knot. Separate the twis
conductors of the tie wires, of which about
inches should remain. Pull the line wire to pro
sag and hold against the clove hitch or square kn
For normal spans (see TM 11–462 for span len
and sag tables) weave the tie wire on the line w
for a distance of at least 8 inches in both directi
and terminate in square knots. For long spans,
length of the weave should be increased. Trim
excess wire from the square knots. The comple
tie should appear as shown in figure 41. This tie
can be used for corner supports with no change
the method of tying. It may be used with W

VD–1 ( )/TT or Wire W–130–( ). Follow the ame procedure as above, but instead of using field vire in the ties, use wire of the same type as the ircuit.

(2) The advantages of weave tying are—

(*a*) Reduces chaffing of the line wire to a minmum.

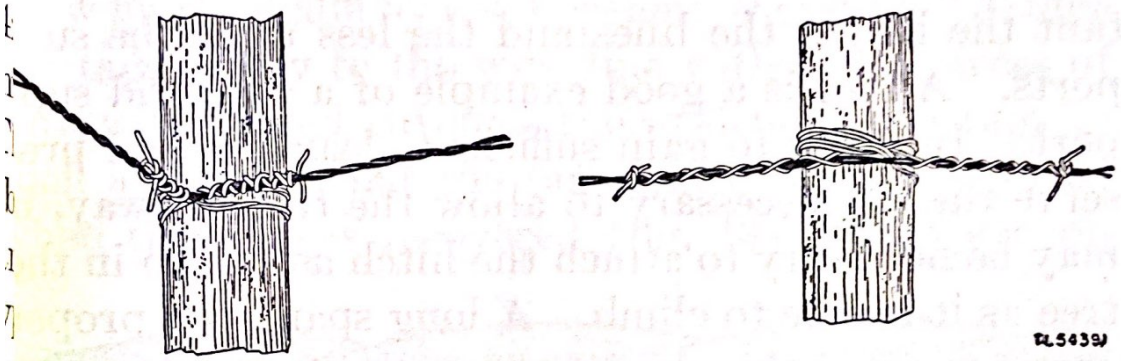


Figure 41. Weave tie used with field wire.

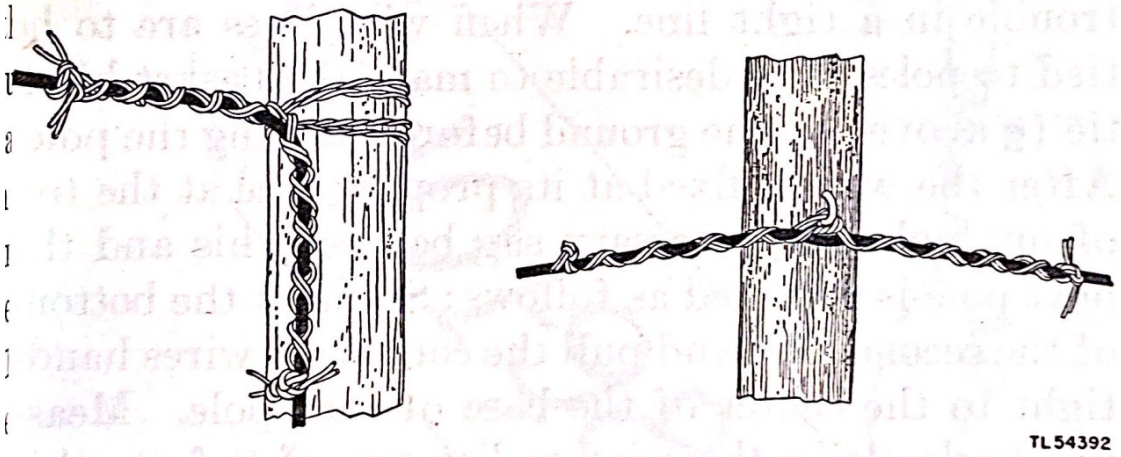


Figure 42. Weave tie used with field cable.

(*b*) Longitudinal strain is taken up entirely by the line wire. The tie supports the vertical weight of the line.

(*c*) Facilitates maintenance in that an overhead line can be dropped to the ground for a close visual inspection and then replaced in the same position with the same tie wire.

(*d*) May be used on any size tree or other support.

j. Sag in line. Sag in the line is one of the important factors affecting the performance o line. Lines inadequately sagged are a con source of trouble. Give special attention to ob ing proper sag. For example, a 100-foot spa spiral-four on poles at 60° F. should be given inch sag. This becomes increasingly more im tant the longer the lines and the less rigid the ports. A tree is a good example of a nonrigid port. In order to gain sufficient clearance and serve the sag necessary to allow the tree to swa may be necessary to attach the hitch as far up in tree as it is safe to climb. A long span with p sag is much better than a short, tight span bet two trees. The sway of the trees will soon c trouble in a tight line. When wire lines are t tied to poles, it is desirable to make the basket h tie (**g** above) on the ground before climbing the p After the wire is fixed at its proper place at the of one pole, the necessary sag between this and next pole is obtained as follows: Stand at the bot of the second pole and pull the conductor wires ha tight to the center of the base of that pole. M ure back along the wire a distance of 2 feet; marks the point where the basket weave is to anchored. If this is to be a tie in midsection of line, the second basket hitch will be made at the sa time. This will provide ample sag in the line allow the conductor wires to loop around the p (fig. 39). All lines in a given span should sag al For sag tables see TM 11–369 and TM 11–371.

k. Field cable ties. Complete instructions 5- and 10-pair rubber-covered cable ties are inclu

TM 11–371. For information on spiral-four cable es, see TM 11–369.

8. CIRCUIT MARKING TAGS. a. Tag the field wire ircuits to assist in recognition. Mark the tags to ow the designation of the circuit (par. 9). The gs are of some water-repellent substance that will ow marks made by a soft pencil or crayon. Attach e tags firmly to the wire line with short pieces of ft wire passed through the eyelets of the tags in ch a manner that the tags can be easily removed hen the wire is recovered (fig. 43). Tags are re-

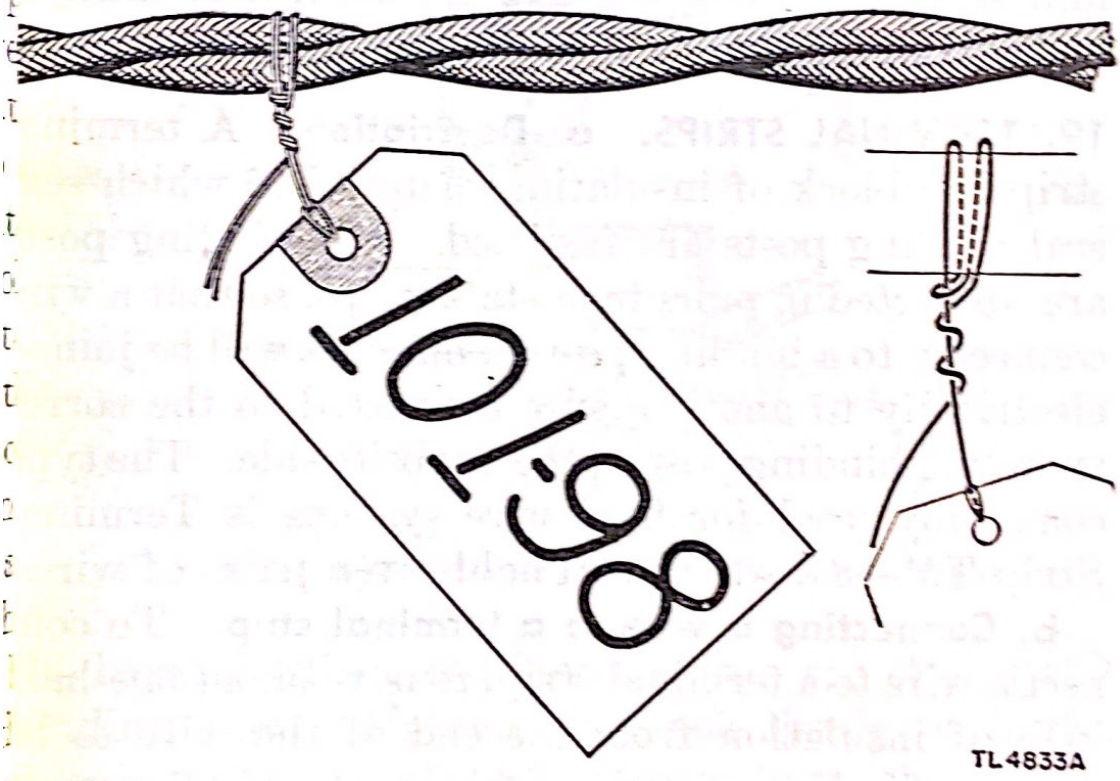


Figure 43. Circuit marking tag.

quired where the wire line connects to an instrument or terminal strip and are attached about 1 foot from such equipment. Tags are placed also at frequent intervals along the wire, particularly where circuits parallel each other for a long distance; where circuits

leave the main route; where wire is buried; and w
the type of construction changes as from surfa
overhead. The tag, MC–72, is presently issued; h
ever, new plastic colored tags may soon be appr
and issued.

b. Tag trunk and long local circuits with the c
plete designation of the circuit. Tag local teleph
circuits with the local telephone number. Omit c
text designations of units from tags for secrecy
security. Substitute some means of recognition, s
as colored tags, notched tags, tags having distinc
shapes, or tags bearing the switchboard name of
unit served. If colored tags are used, they must
identifiable at night with available light sources.

19. TERMINAL STRIPS. a. Description. A termi
strip is a block of insulating material to which s
eral binding posts are fastened. The binding po
are connected in pairs by metals strips, so that a w
connected to a binding post on one side will be joi
electrically to another wire connected to the cor
sponding binding post on the opposite side. The ty
commonly used for field wire systems is Termi
Strip TM–184, which will hold seven pairs of wi

b. Connecting a wire to a terminal strip. To c
nect a wire to a terminal strip, remove about one-h
inch of insulation from the end of the wire to
connected. Unscrew the knob on the binding p
to its fullest extent. Insert the end of the wire i
the slot so that the wire projects through the bi
ing post. A sketch of part of a terminal strip
illustrated in figure 44. As an alternate method,
move about 1 inch of insulation from the wire (le
ing about 1 inch of insulation on the end), dou

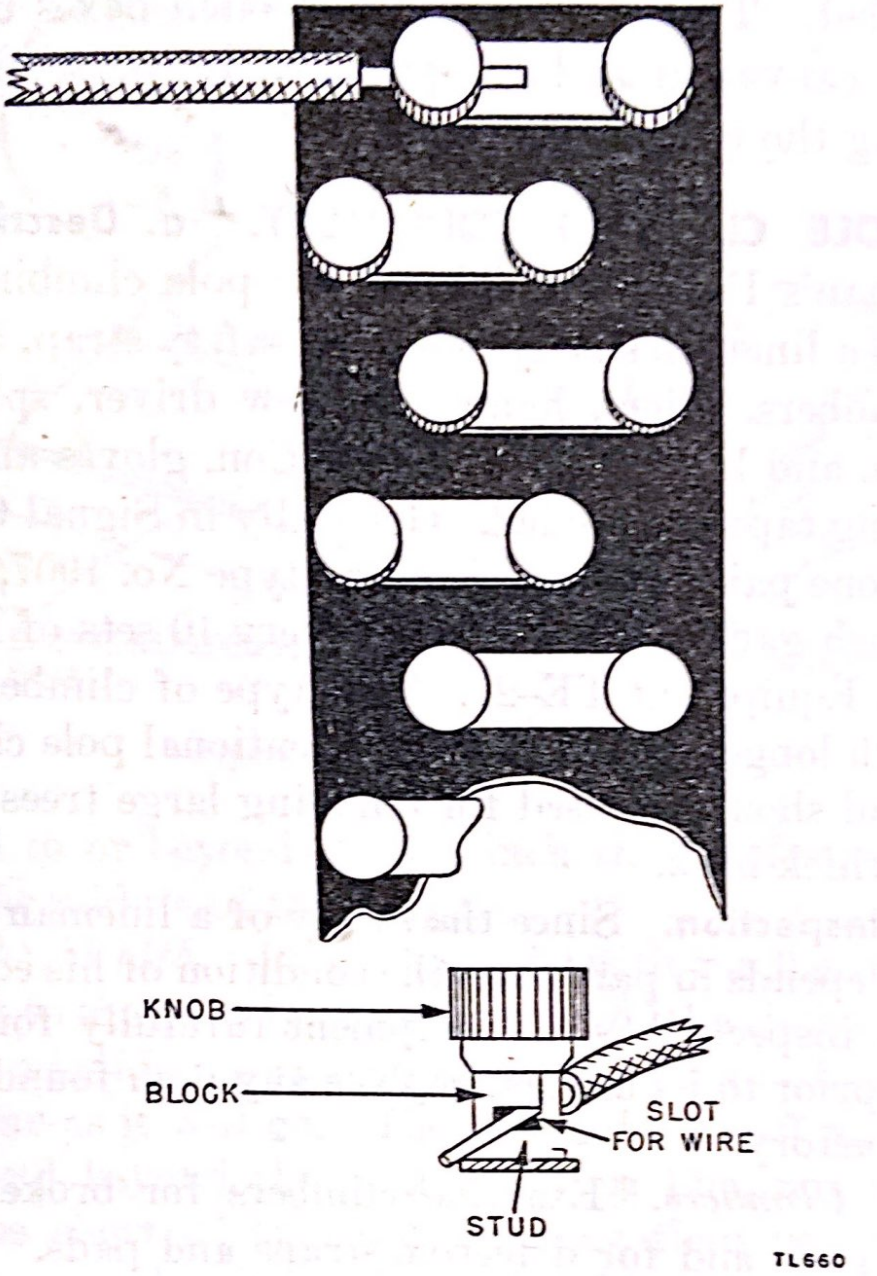


Figure 44. Wire connected to a terminal strip.

the bared portion, and insert it into the slot of the binding post. Tighten the knob firmly with the fingers, clamping the wires securely in the slot so that a good electrical contact is secured (fig. 71). Do not use pliers to tighten or unscrew the knob; this may strip the threads on the binding post.

c. Protection for terminal strips. Terminal strips mounted in the open and subject to the effects of weather must be protected. No prescribed cover is

provided. Therefore suitable wooden boxes or vaged canvas must be improvised by personnel stalling the terminal strips.

20. POLE CLIMBING EQUIPMENT. a. Descript Lineman's Equipment TE–21 for pole climbing cludes a lineman's body belt with safety strap, a p of climbers, pliers, hammer, screw driver, splic clamp, and lug wrench. In addition, gloves and sulating tape are needed. Generally in Signal Co units one pair of Klein climbers, type No. 1907, w 5½-inch gaffs, are issued with every 10 sets of Li man's Equipment TE–21. This type of climber h a much longer gaff than the conventional pole clim ers and should be used for climbing large trees th have thick bark.

b. Inspection. Since the safety of a lineman on pole depends in part upon the condition of his equ ment, inspect all such equipment carefully for d fects prior to its use and replace any item found u satisfactory.

(1) *Climbers.* Examine climbers for broken loose gaffs and for defective straps and pads. T gaffs should be sharp and of the proper dimensio Gaff Gauge TL–144 (fig. 45) is used to determine t important gaff dimensions as follows: the leng along the inside surface; the width or distances ½ inch and 1 inch from the point; and the thic nesses at distances of ½ inch and 1 inch from t point. Make these measurements as follows:

(*a*) *Length.* Place the gauge on the flat surfa of the gaff with a short edge of the gauge held tight against the crotch. The point of the gaff must c

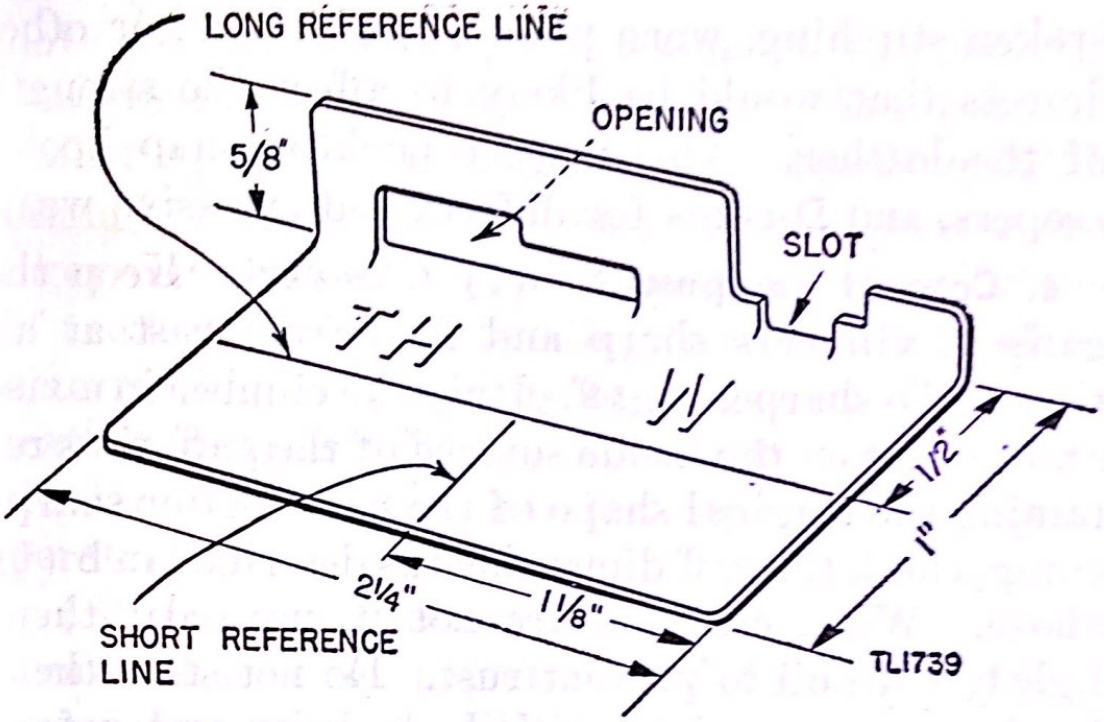


Figure 45. Gaff Gauge TL–144

tend to or beyond the 1⅛-inch short reference line at the middle of the gauge.

(*b*) *Width.* Place the gaff (with the flat surface next to the gauge) in the smaller of the slots marked W and slide the gauge toward the crotch of the gaff as far as it will go. The point of the gaff must not extend beyond the long reference line, nor should it be short of this line by more than five thirty-seconds inch. Next place the gaff in the larger of the slots marked W and slide the gauge toward the crotch of the gaff as far as it will go. The point of the gaff must not extend beyond the far edge of the gauge, nor should it be short of the edge by more than five thirty-seconds inch.

(*c*) *Thickness.* Check the thickness of the gaff in the same manner as the width, using the openings marked TH.

(2) *Lineman's belt.* Examine the lineman's body belt and safety strap before use for cracks, cuts, tears,

broken stitching, worn places, loose rivets, or ot
defects that would be likely to affect the stren
of the leather. Also inspect buckles, snap ho
keepers, and D-rings for defects and excessive we

c. Care of equipment. (1) *Climbers.* Keep
gaffs of climbers sharp and free from rust at
times. To sharpen a gaff, clamp the climber in a v
and file flat on the inside surface of the gaff, thus
taining the original shape of the gaff. After sha
ening, check the gaff dimensions as described in **b**
above. When climbers are not in use, coat th
lightly with oil to prevent rust. Do not store th
in the same container with body belts and safe
straps, because the sharp gaffs may damage t
leather equipment.

(2) *Leather belts and straps.* Keep the body be
safety strap, and climber straps clean, soft, and p
able by the use of saddle soap or by washing tho
oughly with the lather from a neutral soap (su
as castile); this removes embedded dirt and perspir
tion. Wipe the leather dry and oil sparingly wi
neat's-foot oil. Do not use mineral oil or grease. I
not subject the leather parts to excessive heat
standing near an open fire while equipment is bei
worn or by hanging the belt on or near hot stea
pipes. These instructions do not apply to canv
body belts and safety straps, which may be issu
in lieu of leather equipment.

(3) *Treatment under special climatic conditio*
(*a*) *Arctic.* Clean and dress leather parts every
months or more frequently if leather equipment
comes wet or is in contact with paint. Remove pa
as soon as possible because it damages leather. I

move creosote to avoid possible contact with clothing. Observe the following precautions: Avoid drying leather equipment in temperatures exceeding 72° F. Changing from subzero temperatures to temperatures exceeding 72° F. will cause rapid deterioration of the leather. Make bending tests ((4) below) for determining the pliability of leather only when the leather contains sufficient oil. Never make these tests directly after leather has been out in subzero temperatures.

(*d*) *Desert.* Clean and dress leather every month, more often if equipment is used frequently. More frequent treatment will minimize the abrasive effects of sand and dirt and prevent the leather from drying out.

(*c*) *Tropics.* Inspect moistureproofed and fungiproofed leather periodically at the end of the first 6 months of use after treatment. Make these inspections to see that the leather is retaining its moisture- and fungus-resistant qualities as well as its flexibility. Leather dubbing supports fungus growth. Do not use it to moistureproof leather in areas where fungus growth is prevalent. (See TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for complete information on treating leather to prevent damage from moisture and fungus growth.)

(4) *Bending test for leather.* Determine the presence of cracks and the pliability of leather by bending as follows:

(*a*) *Safety straps.* With the smooth side (grain side) out, bend straps over a mandrel not less than three-fourths inch in diameter (such as ¾-inch guy

rod). Make the test in at least three places: n each end and in the middle of the strap. Sli cracks will normally appear on the surface.

(*b*) *Body belts.* Bend at points capable of be bent without great effort, such as under the leat tool loops and tongue strap. Bending belts over small a mandrel may result in the development damaging cracks. Always keep the grain side of belt on top when bending.

Caution: Never attempt to bend dry leather. A ply oil as described in (2) above.

d. Size and adjustment. (1) *Climbers.* The s of climbers is determined by measured length inches, from the instep to the end of the leg in The correct size to use is one measuring one-half in less, in length, than the distance from the proje ing bone on the inside of the knee to the arch of t shoe. Climbers are bent to conform to the weare leg so that they are comfortable. Straps are faster snugly around the calf and ankle.

(2) *Body belt and safety strap.* On a body be of the proper size, the D-rings will be just behind t projecting portions of the lineman's hipbones. T body belt is worn over the hips and tight enough prevent slipping (figs. 46 and 47). If the linem is right-handed, he snaps both ends of the safe strap to the left-hand D-rings; if left-handed, snaps the ends to the right-hand ring. The doub end of the strap is snapped to the D-ring, with t keeper toward the rear, and remains hooked at times. The fixed end of the strap is snapped on t D-ring with the keeper toward the front and abo the snap hook of the double end. Before climbi

Figure 46. Lineman with equipment, front view.

the pole, adjust the safety strap to the proper length: Stand at the base of the pole upon which the work is to be done and engage the gaffs of the climbers; pass the safety strap around the pole, as described in paragraph 22**d**, and fasten the strap. Lean back, keeping the torso about parallel to the pole until the weight is supported by the safety strap. When the safety strap is adjusted properly, the palms of the hands will rest on the far side of the pole without overlapping.

21. POLE CLIMBING SAFEGUARDS. a. On the gr
Be careful at all times when wearing climbe
gaffs can cause serious wounds. When wearing
be careful not to step on the feet of other per
Wear climbers only while climbing and workin
poles. The habit of wearing climbers while wo
on the ground or riding in a vehicle frequentl
sults in serious injury.

b. Aloft. While aloft, always use the safety s
not only to prevent falling but also to facilitate w
ing with minimum fatigue. Be careful not to
tools or other equipment while on a pole.

Figure 47. Lineman with equipment, rear view.

c. Testing poles. Poles which have been in service for long periods of time may be defective and may break under unbalanced loads due to climbing or working. If a pole breaks, communication may be disrupted, material destroyed, and personnel injured. Therefore, test the poles prior to climbing and if they are found to be defective, provide them with temporary supports. It is unnecessary to test an in-line or a properly guyed pole attached to a suspension strand, five power wires, a full cross arm of heavy telegraph wires, or a four-way, storm-guyed pole.

(1) A suitable test for soundness of a pole can be made by thrusting a pike pole (16-foot) in at an angle of 45°. By applying sufficient pressure to the pike pole, gently rock the pole being tested back and forth at right angles to the line. If the pole cracks or breaks, it is unsafe for climbing without temporary bracing. Such bracing can be provided by means of four pike poles, by guying to trees or other sound poles, or by support from a derrick truck.

(2) Do not apply the pike pole test if the pole will crush material in falling; do not rock the pole so vigorously that the wires swing together and cause trouble in the circuits. The pole also can be tested for soundness by prodding the butt, just below the ground line, with a screw-driver or bar. This test will reveal rotten wood if the pole has commenced to decay at that point. If the butt is broken or decayed, secure the bottom of the pole by driving bars into the ground around the pole.

22. CLIMBING POLES. In the following text, it is assumed that the lineman is right-handed. A left-

handed lineman performs the operations below
the opposite hands and legs.

a. General. In climbing a pole, keep the
slightly bent, with the hips farther from the
than any other portion of the body. To engage
gaffs, whether ascending or descending, thrust
legs inward and downward. To disengage the g
move the legs sharply upward and outward. P
the hands on the far side of the pole. If the ha
overlap, the body is too close to the pole and th
is danger of the gaffs cutting out and causing l
of footing; if the hands are on the sides of
pole, the palms have no purchase, and the arms
under great strain. The weight of the body is c
ried normally and lifted entirely on the gaffs;
arms merely balance the climber. If the hips are
close to the pole, the legs will be parallel to
pole and the gaffs will cut out, removing support
the climber. If the hips are too far out, the ar
are placed under strain since they will be suppo
ing a large portion of the climber's weight. If t
knees touch the pole the gaffs will lose purchase a
cut out.

b. Ascending. (1) Before climbing, circle
pole and inspect it for soundness; also note the lo
tion of wide weather cracks and soft or hard sp
in the wood. Observe any cables, cross arms, or otl
obstructions that may interfere with climbing.
the pole leans, face the direction in which the p
is leaning and climb on the high side.

(2) Grasp the pole and raise the left foot abo
10 inches from the ground, keeping the gaff abou
inch from the pole. With a downward thrust, j

the gaff of the climber into the face of the pole at a point about 8 inches from the ground (fig. 48).

(3) Lift the weight of the body on the gaff by straightening the leg. While the weight of the body

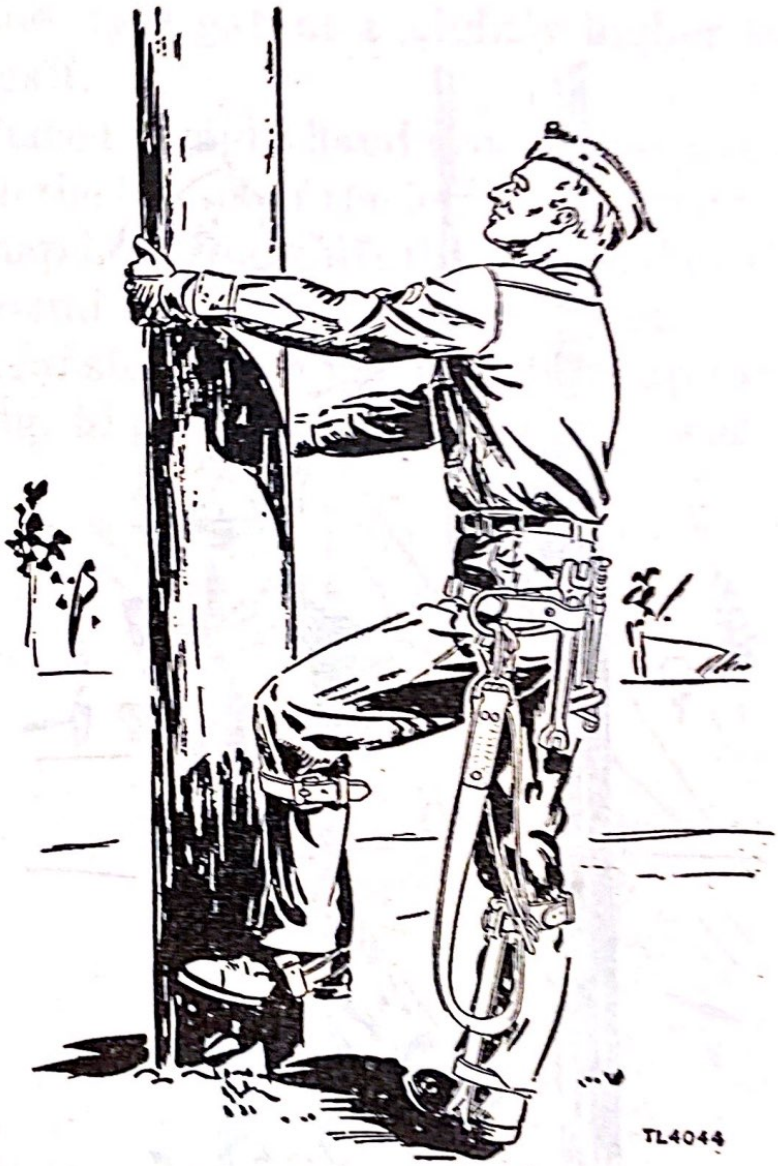


Figure 48. Beginning the climb.

is on one leg, keep that knee straight and away from the pole. Raise the other leg and corresponding arm and then drive the climber downward and inward to seat the gaff firmly (fig. 49).

(4) The gaff is disengaged by a sharp upward and outward motion of the leg. In taking the next step

raise the left leg and right arm (or vice ve
together.

(5) Reengage the free gaff firmly and cont
climbing to the desired height. While ascendin

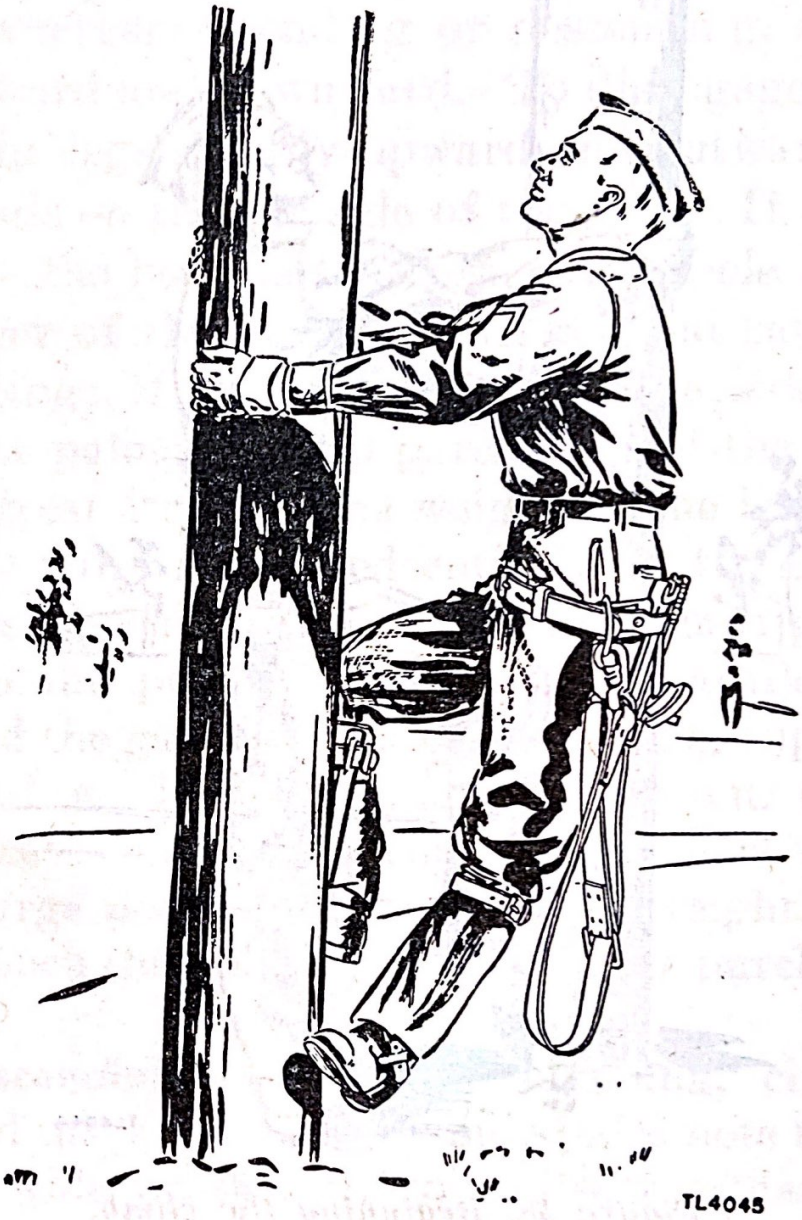


Figure 49. Climbing.

ways look up to see what obstructions may be i
the way.

c. Descending. The motions in descending are th
reverse of those in ascending. Look down to see tha
the way is clear below.

d. Fastening safety strap. To fasten the safety strap when the desired height on the pole has been reached proceed as follows:

(1) Shift the weight partially to the left foot and engage the right gaff at a slightly higher level than the left gaff.

(2) Place the right hand around the pole (fig. 50) and, with the thumb of the left hand, open the keeper on the snap hook and shift the fixed end of the safety strap around the pole to the right hand.

(3) Transfer the snap hook and strap to the right hand (fig. 51) and balance the body with the left hand.

Figure 50. Unhooking safety strap.

Figure 51. Transferring safety strap to right hand.

(4) Hold the strap up loosely on the pole at abo the proper height and, using the right hand, pull t strap up to the right-hand D-ring.

(5) Snap the hook on the right-hand D-ring, usi the heel of the right hand (fig. 52).

Caution: It is essential to *see* that the snap hook properly engaged. *Do not assume*, merely from t snap of the keeper, that the D-ring has been engage by the snap hook.

(6) Reengage the right gaff at the same level a the left gaff. Then lean back and carefully place th full weight of the body on the safety strap, keepin

the hands firmly gripped about the safety strap until it has been tested (fig. 53).

e. Unfastening safety strap. To unfasten the strap reverse the fastening procedure.

(1) Move the right gaff up and reengage it at a slightly higher level than the left gaff.

(2) Hold the pole with the left hand. With the right elbow up, the hand twisted, and the thumb held downward, depress the keeper and disengage the snap hook from the right-hand D-ring.

Figure 52. Snapping hook on D–ring.

Figure 53. Testing the safety strap.

(3) Pass the strap around the pole to the le hand, balancing the body with the right hand.

(4) Snap the hook to the left-hand D-ring with single downward movement.

f. Precautions. Beginners should perform the operations near the ground until sufficient practi enables them to pass the safety strap around the po with speed and precision. Not until then shou they attempt to carry out these operations alof While the lineman is working at the top of the pol the safety strap is never placed above the top cro

arm nor within 6 inches of the top. If the outer wires of a cross arm are to be reached, hook the safety strap just below the cross arm. Thrust the body between two conductors so that the head and shoulders are above the level of the cross arm (fig. 54).

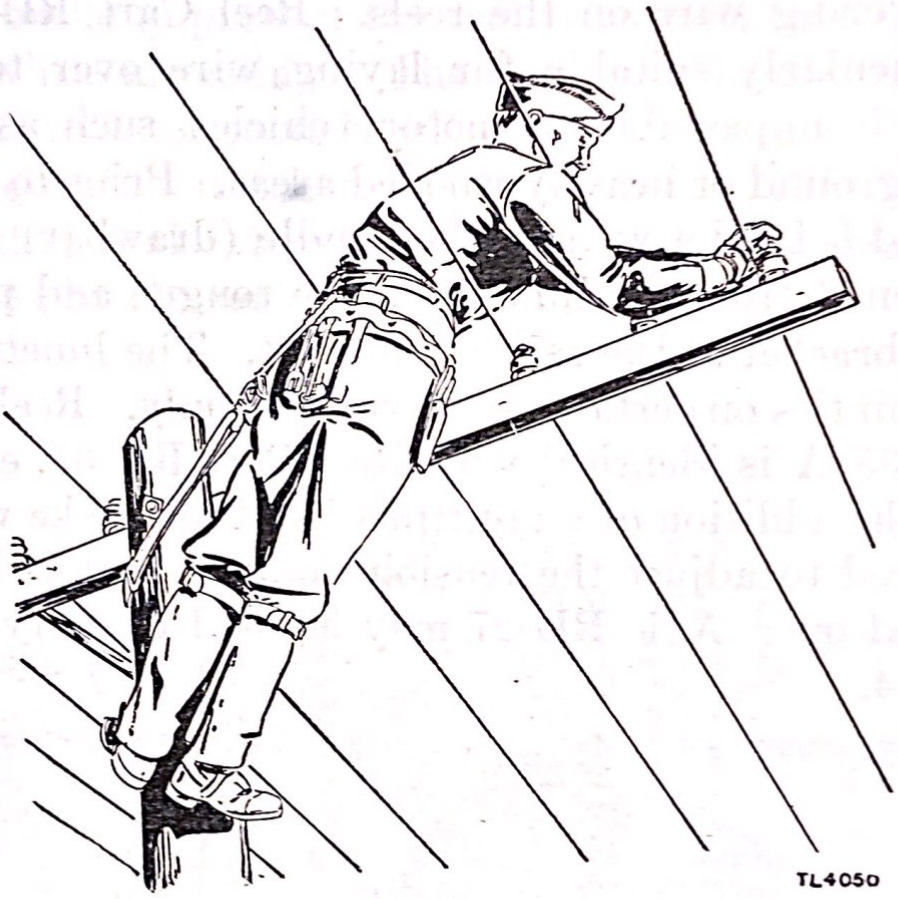


Figure 54. Working on outer wire of cross arm.

23. WIRE-LAYING EQUIPMENT. a. General. Field wire is carried forward by and laid from motor vehicles or animals carrying reel units; from hand-drawn or vehicle-towed reel carts; from reels on axles carried by hand; and from bundles or coils carried by hand. The actual method used depends upon the equipment available, the condition of the roads and terrain, the amount of traffic, and the tactical situation.

b. Reel Carts RL–35 and RL–35–A. Reel Cart
35 (fig. 55) is a two-wheel cart, with pneumatic ti
which may be pulled by hand or towed behi
vehicle. Each reel cart carries three Reels DR–
one Reel DR–5, which are removable. The axl
equipped with a detachable hand crank for use w
recovering wire on the reels. Reel Cart RL–3
particularly suitable for laying wire over ter
that is impassable to motor vehicles, such as
soft ground or heavily wooded areas. Prior to be
towed behind a vehicle, the handle (drawbar) is
fastened from the lunette on the tongue and pl
in a bracket at the rear of the cart. The lunett
the pintles on certain small vehicles only. Reel C
RL–35–A is identical with Reel Cart RL–35, ex
for the addition of a multiple-disk-type brake wh
is used to adjust the tension on wire that is be
payed out. Axle RL–27 may be used to carry R
DR–4.

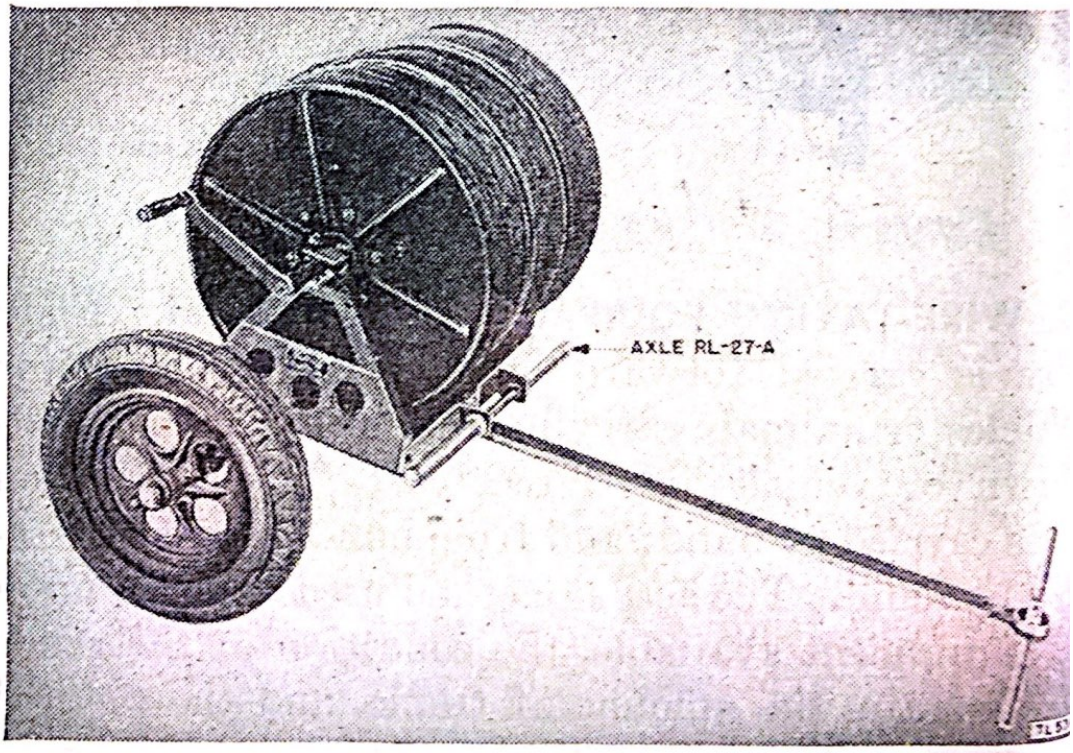


Figure 55. Reel Cart RL–35.

c. Reel Unit RL–31. (1) Reel Unit RL–31 (fig. 56) is a lightweight portable frame designed to facilitate the reeling and unreeling of field wire and cable by hand. The reel unit contains bearings for a steel axle that is equipped with a removable hand crank. The first models of this reel unit had an automatic drag brake to prevent the reel from turning too rapidly while unreeling. The automatic brake was replaced in later models with a hand-operated brake permanently attached to the frame. This hand-operated brake does not operate unless pressure is applied by the reel unit operator.

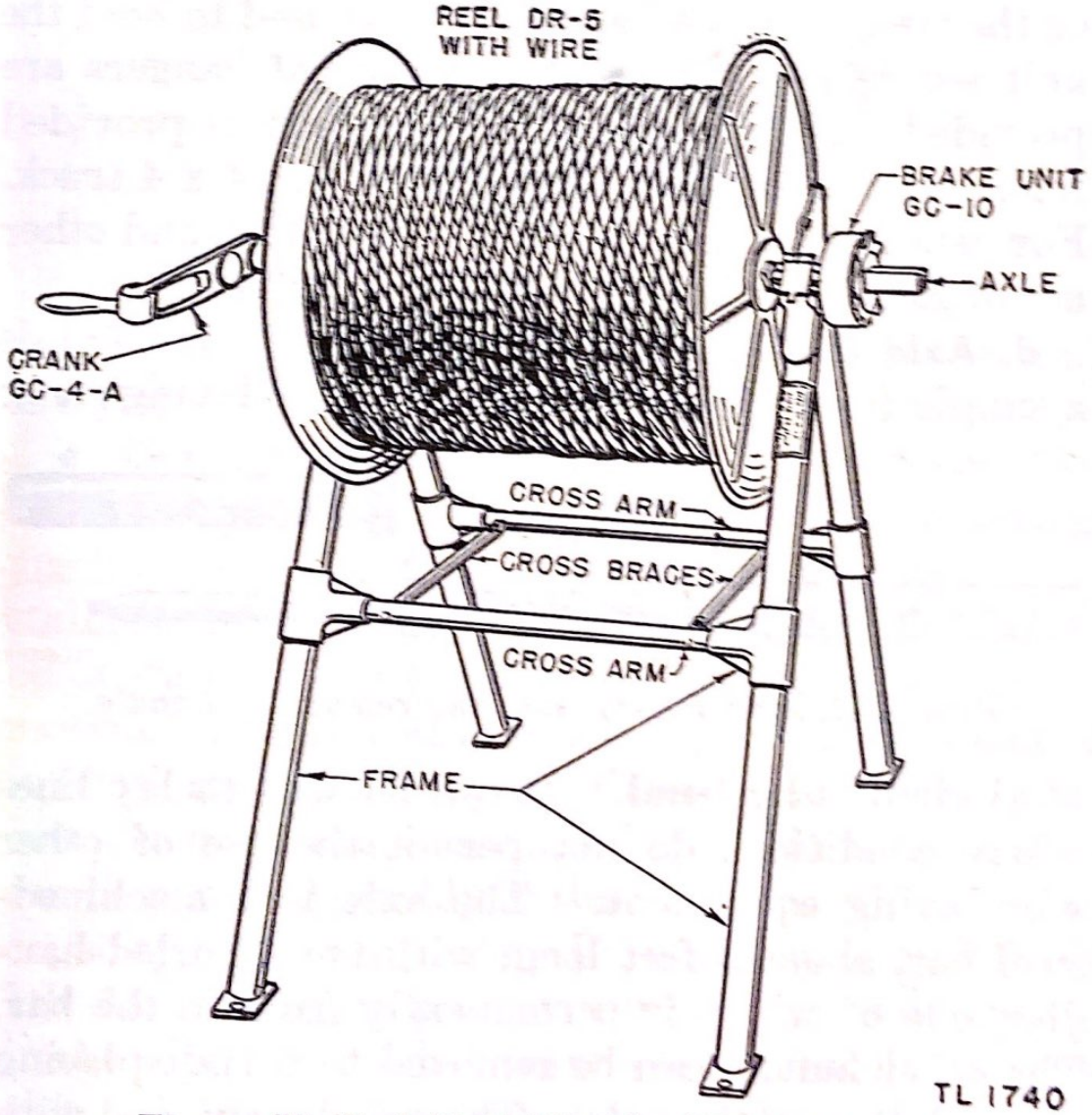


Figure 56. Reel Unit RL–31 with Reel DR–5.

(2) All models of Reel Unit RL–31 can be u in the same manner. Reels DR–5, DR–7, DR- or two Reels DR–4 may be used with Reel U RL–31. However, when wire is being laid simul neously from two Reels DR–4, both reels must c tain the same amount of wire. If this precautio not observed, the line from the reel with the grea amount of wire will have excessive slack.

(3) Reel Unit RL–31 may be set up on the grou mounted in a vehicle, or attached to the tailboard a vehicle. The type of vehicle on which the unit to be mounted determines whether the four toe pla or the two tailboard hangers will be used to hold t unit securely in place. Both types of hangers a provided. A special kit of attachments is provid for mounting the reel unit on a ¼-ton, 4 x 4 truc For detailed instructions on the mounting and oth use of Reel Unit RL–31, refer to TM 11–362.

d. Axle RL–27. Axle RL–27 (figs. 57 and 58) a simple form of wire-laying device for laying sho

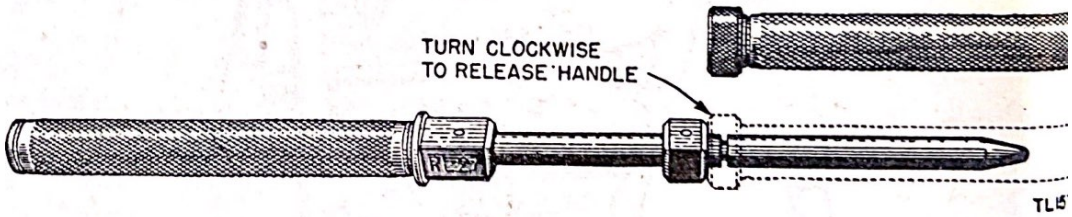


Figure 57. Axle RL–27, showing removable handle.

local circuits by hand. It can be used to lay lin where conditions do not permit the use of oth wire-laying equipment. The axle is a machine steel bar, about 2 feet long, with two knurled ha dles, one of which is permanently fixed to the b The other handle can be removed to permit placi a Reel DR–4 on the axle. The axle is equipped wi

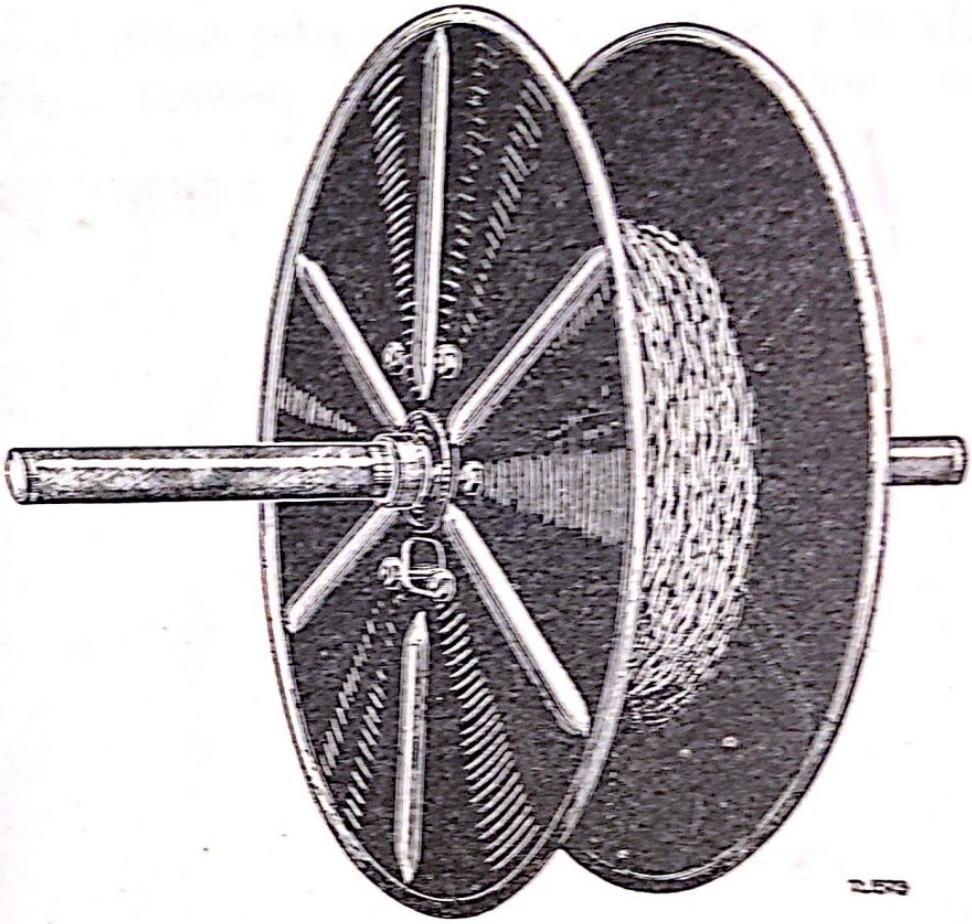
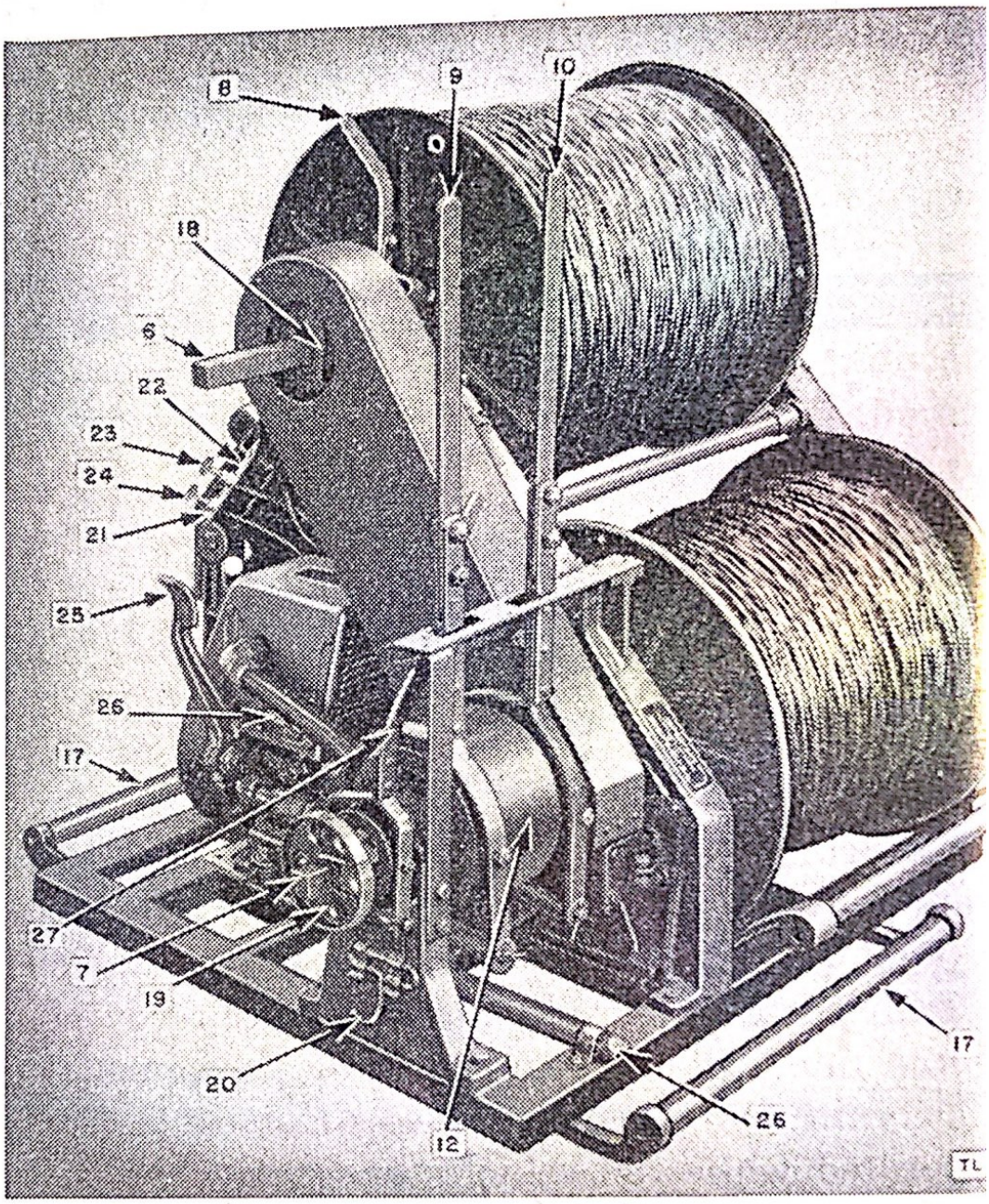


Figure 58. Axle RL–27 with Reel DR–4.

roller bearings. Axle RL–27–B is a later model and is equipped with a crank for reeling in wire.

e. Reel Unit RL–26. (1) Reel Unit RL–26 (fig. 59) is a transportable wire-laying and wire-recovering machine intended for temporary or permanent installation in motor vehicles. Reel Unit RL–26 may be operated while the vehicles are stationary or in motion. The unit also may be operated dismounted in temporary stationary positions on the ground. All component parts are assembled on a skid frame which can be installed quickly in the back of a vehicle. The capacity of the unit is two Reels DR–5, or two Reels DR–15, mounted in position for paying out or reeling in the wire. The individual reels are readily replaceable. The wire can be payed out from either reel

singly or from both simultaneously, and means provided for braking the reels to prevent overs



6 and 7. Axles for reels.
8. Secondary clutch lever for upper axle.
9. Main clutch lever for lower axle.
10. Main clutch lever for upper axle.
12. Clutch drum.
17. Skid frame.
18 and 19. Axle latches.
20. Axle tools.
21. Control panel.
22. Ignition switch.
23. Throttle.
24. Choke.
25. Pedal starter.
26. Exhaust pipe.
27. Secondary clutch for l axle.

Figure 59. Reel Unit RL–26 with two Reels DR–5 in posi

ing. The small gasoline engine provides power to cover the wire on either reel individually or on both els simultaneously. When the engine is inoperative, wire can be recovered by hand cranking. The eight of Reel Unit RL–26, without reels, is about 46 pounds. The unit fully loaded with 2 miles of ire weighs approximately 690 pounds.

(2) The method of laying wire from Reel Unit L–26 mounted in a 2½-ton truck is shown in figure). Under certain conditions, it may be desirable to ount this reel unit in a 1½-ton truck or a ¾-ton eapons carrier. More complete descriptions of the peration and maintenance of this reel unit may be ound in TM 11–360.

f. Reel Equipment CE–11. Reel Equipment CE–11 fig. 61) consists of a Reel DR–8, carrying handles or the reel which incorporate the support bearings nd a square-shaft axle with crank for rewinding, a ound-powered telephone Handset TS–10, and carrying straps. The method of carrying the handset nown in figure 61 permits the operator to hear a prerranged signal for attracting his attention without ne necessity of continuously holding the handset to is ear. To lay wire with this equipment, unsnap the andles from the carrying straps and carry the reel n the hand at the side of the body, allowing the reel o rotate freely. The equipment may also be strapped o the back for wire laying. To recover wire, snap ne carrying handles to the carrying straps and rotate he reel by means of the crank and axle while walking oward the opposite end of the line. See TM 11–2250 or complete information on this equipment.

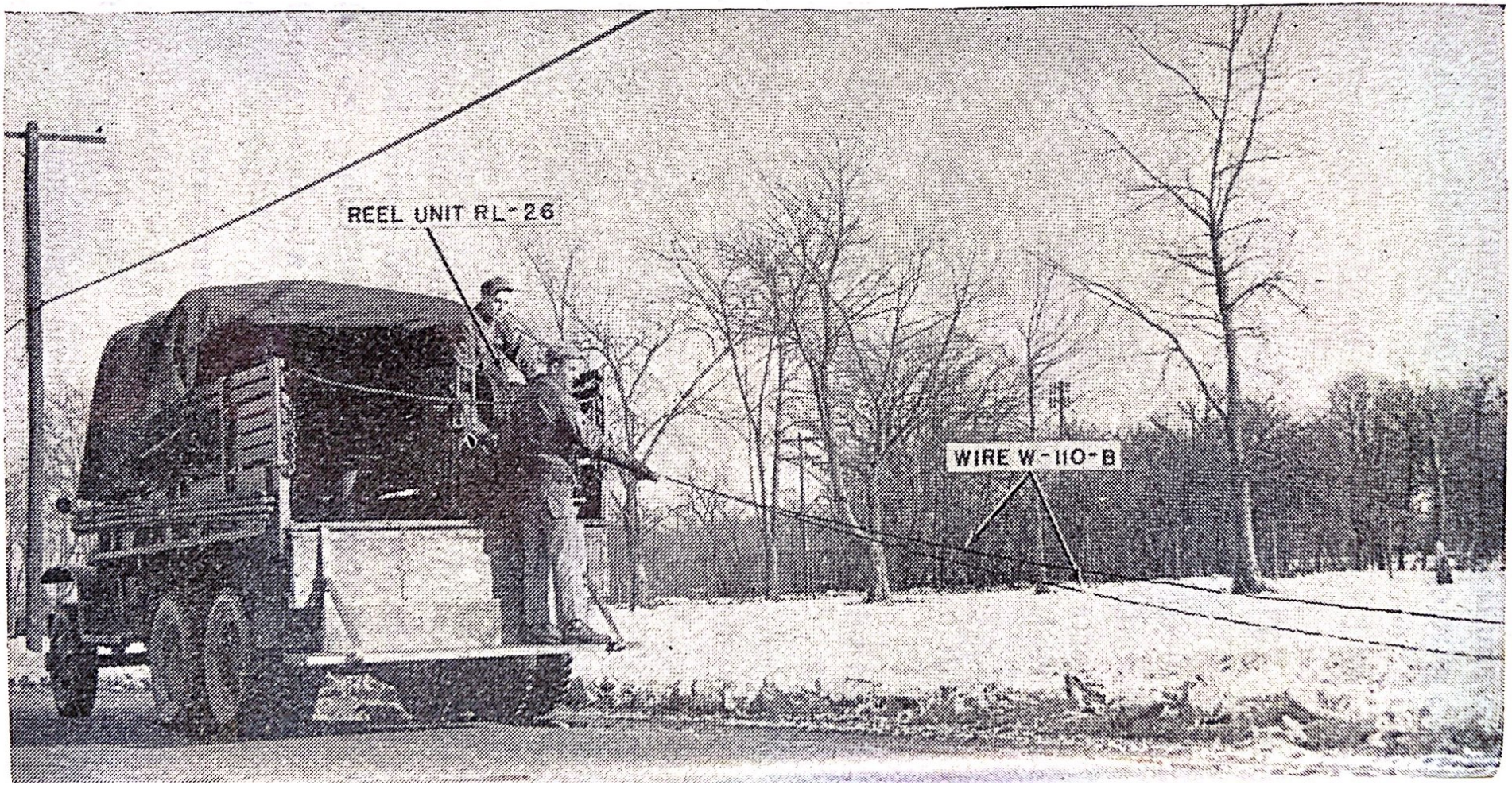

REEL UNIT RL-26
WIRE W-110-B

Figure 61. Reel Equipment CE–11.

g. Commercial spools. Wire issued on commercial spools may be laid by inserting an iron bar through the axle opening in the spool and paying out the wire from a vehicle; or two men may carry the spool on the bar and pay out the wire while walking along the route.

h. Pack-saddle carriers. Pack-saddle carri
available for transporting several Reels DR-4
back of a pack animal. Field wire may be pa
or reeled in directly from the mounted reels.

i. Maintenance of wire-laying equipment.
odic inspection and maintenance of wire-
equipment is essential for efficient operation,
applies to all wire-laying equipment and parti
to engnie-operated reels. For details of maint
procedure, see TM 11–360 and TM 11–362.

j. Wire dispenser. Wire WD–1( )/TT i
wound in expendable dispensers suitable for
from packboard by mountain, ski, or ground
or from liaison type airplane. Wire Dis
MX–306( )/G (fig. 62) with one-half mile o
WD–1( )/TT is 14 inches in diameter, 5 inc
with a 4-inch hole, and may be used where the
pack will not interfere with operations. For
tional information see TM 11–2240. For
purposes, similar dispensers with a canvas cov
be used. Launcher, Rocket 2.36-inch (bazook
the rifle grenade may be used to lay wire fro
dispenser over small streams or ravines ((
(3) below).

(1) Wire is payed out from the center of t
through the hole in the dispenser marked PA
END. The STANDING END pigtail is co
to the user's telephone if communication is
during the laying procedure. In splicing
more dispensers, the standing end of one n
spliced to the payout end of the second unit .(
This type of coil makes laying from vehicles

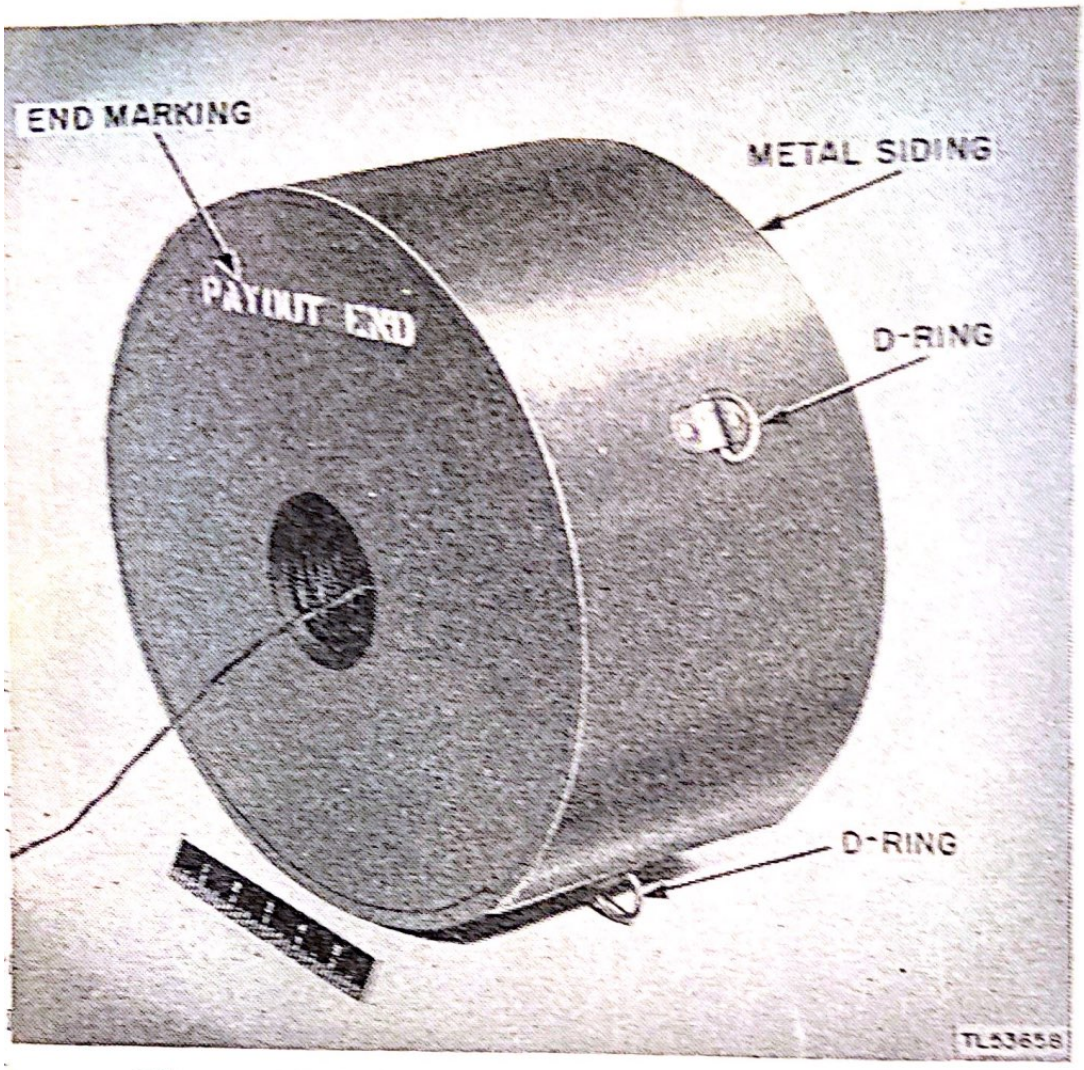


Figure 62. Wire Dispenser MX-306( )/G.

lanes convenient in that all the wire may be pre-)liced for continuous operation in laying. It is ecessary to anchor the payout end for all types of ying.

(2) Launcher, Rocket 2.36-inch (bazooka), may e used to lay wire from wire dispensers. Tie the ayout end of the wire into a loop 1½ inches in iameter, using a square knot. At a point 7 inches om the loop, tie a slip loop about 3 inches in di-neter. Attach the loops over the muzzle of the azooka with two strips of friction tape so that the naller loop is centered within the 3-inch loop and ie muzzle of the bazooka. The pick-up loop will

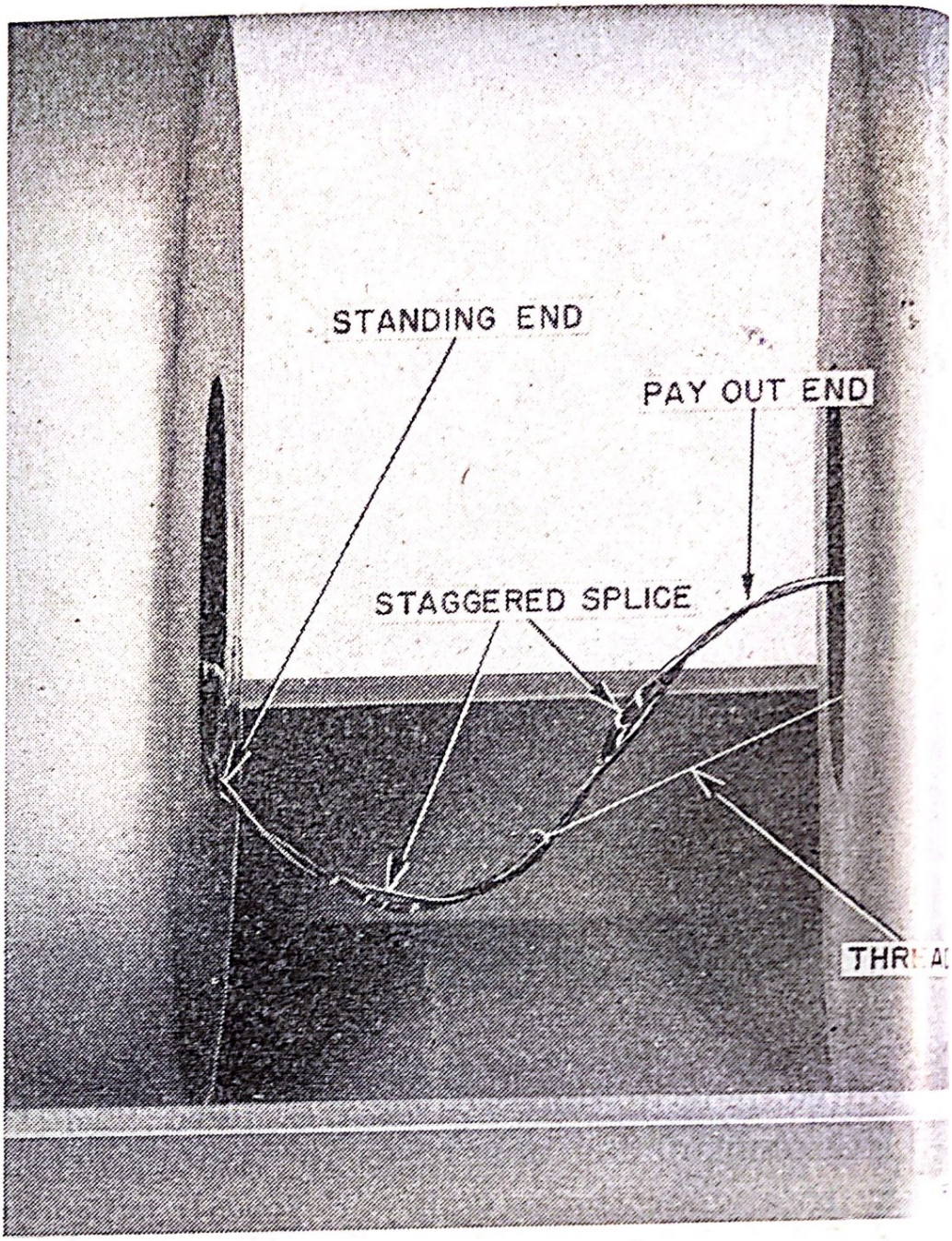


Figure 63. Preparing coils for tandem operation.

catch the nose as the slip loop passes over it to g the body of the projectile passing through muzzle of the bazooka (fig. 64).

(3) The rifle grenade may also be used to lay from these dispensers. Tie the pay-out end of wire to the base of the grenade (fig. 65). Place wire dispenser close to the firing position with payout end in the direction of aim.

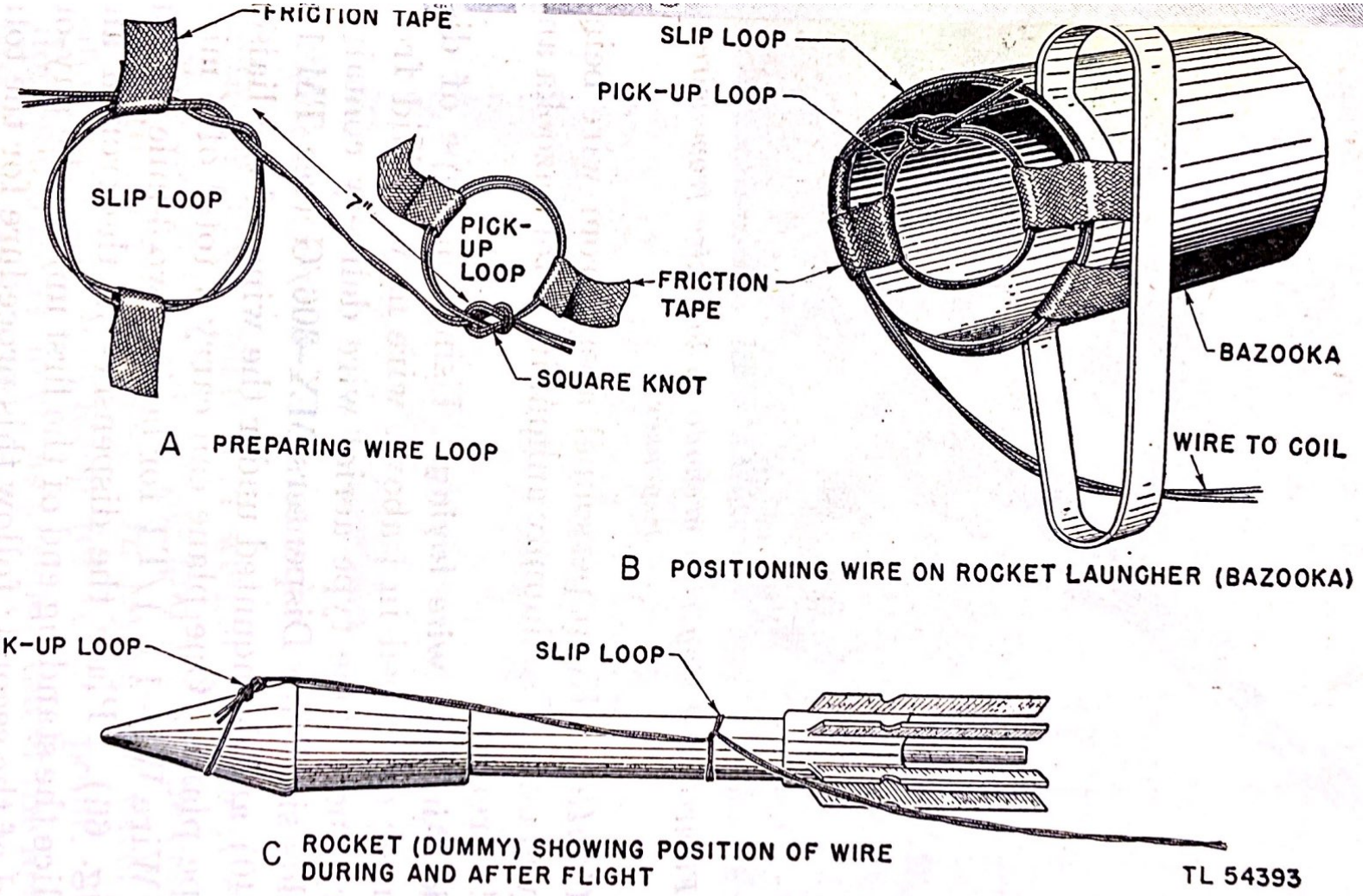


Figure 64. Steps in using Launcher, Rocket 2.36-inch, to lay wire.

Figure 65. Using rifle grenade to lay wire from
dispenser.

Caution: Keep personnel away from wire payed out. Use dummy ammunition for bazook rifle grenade.

k. Airborne wire laying. Using the type penser described in **j** above, wire may be laid airplanes. One type aerial wire delivery co holds six Wire Dispensers MX–306/G (see T 2240) and is mounted under the wing of the type plane. One plane can carry a total of of Wire WD–1 ( )/TT for laying two 3-mile (fig. 66). Place the dispensers in the trou splice the standing end of the first unit to the end of the second; follow this procedure for t number of units. Insert between each unit of slit cardboard of slightly larger diameter t

pening in the center of the coil. The purpose of ıe cardboard is to hold the wire in place and to revent the wire being payed out from lashing back nd picking up the next coil before the first one has een completely expended. Test the continuity of ıe circuit. Place the troughs in the containers with he pay-out end toward the tail of the airplane. Tie he wire from the pay-out end of the dispenser to the

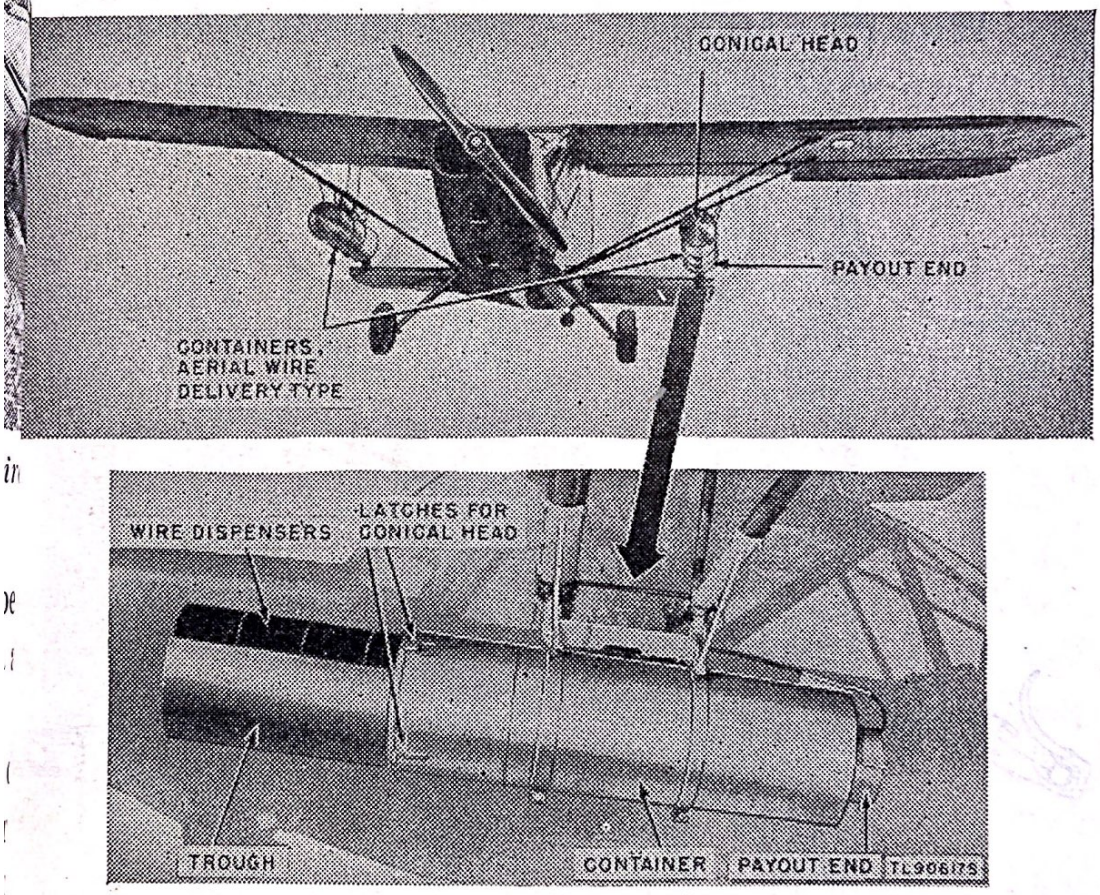


Figure 66. Containers mounted under wings of airplane.

container-release plate and weight. Aline the release plate on the guide rods and insert the release wires to hold it in place. In laying the wire, use panels or other indication for release point. The pilot should fly as slowly as possible and at the lowest altitude possible. The following technique is suggested for establishing communication:

(1) Use each pair of wires as one side, ho
a Telephone EE–8, and test. If one of the pa
shorted, communication is still possible. It wi
provide a better circuit for talking and testing

(2) Next test the left pair as laid by the ai
If this pair proves to be good, go on to the right

(3) If neither pair tests through, return to th
previous test that was satisfactory to check fin

l. Wire Pike MC–123. Wire Pike MC–123 co
of a two-section pole joined by a metal fitting
pin (fig. 67). The top section terminates in a

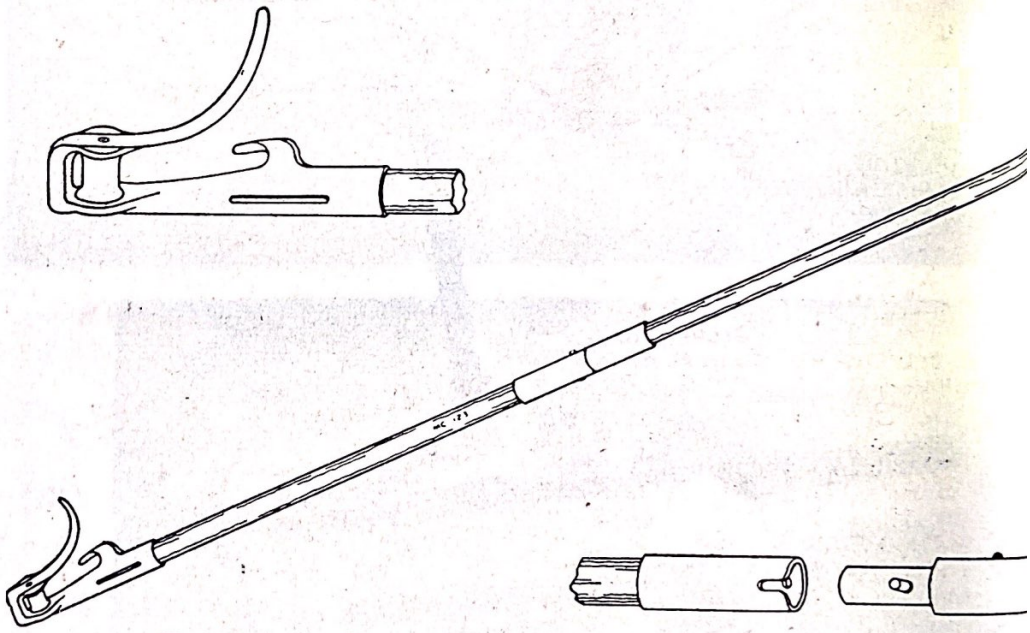


Figure 67. Wire Pike MC–123.

connected to a roller. The wire pike is used
guide to facilitate the handling of field wire in
hicular laying to keep it to the side of the road,
to provide drag and smooth delivery in picking
wire.

**m. Accessory equipment for field wire constru
truck.** All or any of the following parts ma
mounted on a 2½-ton, 6 x 6 cargo truck to conve
into a field wire construction vehicle (fig. 68).

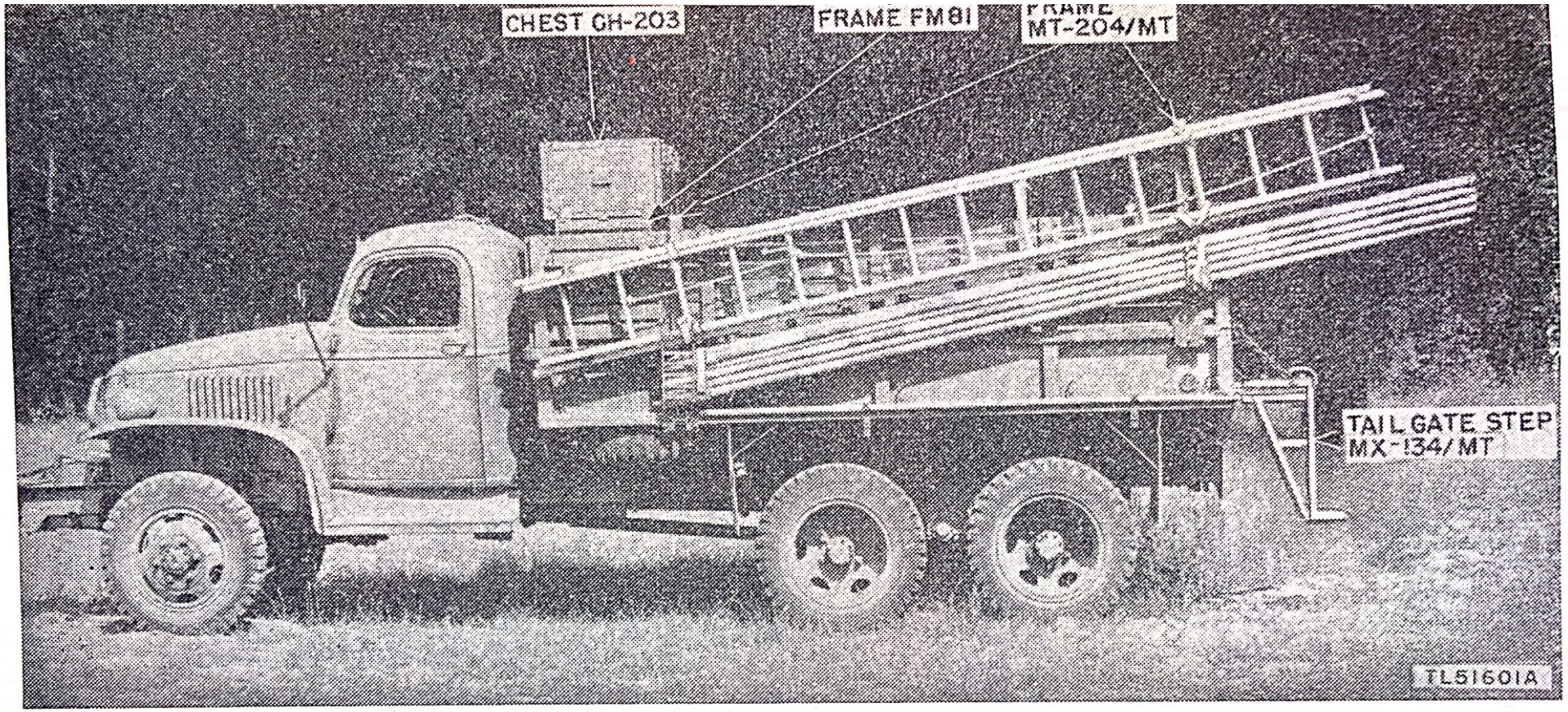


Figure 68. Accessory equipment mounted in standard 2½-ton 6 x 6 cargo truck.

(1) *Reel Frame FM–81.* Reel Frame FM–81 a collapsible steel frame made from standard channels, tees, and angles. The frame has eight compartments for storing eight Reels DR–5 or DR–15.

(2) *Chest CH–203.* Chest CH–203 is a metal bound plywood and wooden chest with three drawers and six compartments for storing climbers, batteries, flashlights, headsets, tools, nuts, bolts, nails, screws, and miscellaneous construction equipment.

(3) *Frame MT–204/MT.* Frame MT–204/MT consists of two sets of steel supports which can be attached easily to the side of a truck. The supports will carry 10 Lance Poles PO–2, 8 Pike Poles PO–(PO–6), 1 Wire Pike MC–123, and 1 ladder LC–1.

(4) *Straps and supports.* Straps keep the poles and ladder in place during transportation. The support will give when empty if struck by obstacles during a move. It way be restored to normal position by manually pushing it into place.

(5) *Tail Gate Step MX–134/MT.* This metal step may be attached to the tail gate of any standard 2½ ton, 6 x 6 cargo truck.

Section II. CONSTRUCTION

24. PLANNING OF WIRE LINES. a. General. The planning of wire lines in any unit is the responsibility of the signal or communication officer of that unit. This planning includes the type of line to be built and the general route to be followed. To determine the type of line to be built, consider the following primary factors: The type of equipment available, the number and quality of circuits required, the length of the line, and the time available for the in-

stallation. To estimate the quality of the proposed line, consider the relative transmission characteristics of the different types of field wire when laid on the ground, when buried, or when installed aerially on overhead supports. Generally, aerial lines give longer transmission ranges and provide more physical protection for the circuit than other types of construction. The time element, however, may limit the use of overhead construction, in which case the wire will have to be laid hastily on the ground.

(1) The reliability of surface line construction is directly proportional to the care used in the installation. Wire lines laid rapidly on the ground without regard for policing will require immediate and continuous maintenance and are seldom justified. On the other hand, surface lines laid carefully, with due consideration to ties, road crossings, and other means of protection, provide a reliable type of line suitable for most combat requirements.

(2) It may be necessary in remote instances to lay the initial wire with only a minimum of policing and then do the proper policing immediately afterwards.

(3) Remember that complete and final policing of wire lines is a separate operation and should in no way affect the rate of placing the wire or delay the establishment of wire communication.

b. Routing. Selection of the route is based on the requirements of the tactical situation and on map study, supplemented by a ground reconnaissance. The route is planned to avoid difficult terrain, since such terrain increases the amount of special construction needed and thereby reduces speed and efficiency. Continuous liaison is maintained with all units en-

gaged in road building and road improvement to avoid routing lines where there is a possibility of damage to the line from road construction. *If it is imperative that wire lines be laid along roads where construction work is being done, maintain coordination with engineer units to guard against unnecessary interruption to wire communication.* Where there is a possibility that the initial type of installation will require a change to a more permanent type, or where the lines may be used again by the same unit, or another unit, after the movement of command posts, choose the route which will make the change as easy as possible. Avoid compact or built-up residential areas wherever possible. Wire construction among buildings is difficult to install and maintain and is sometimes an invitation to sabotage in occupied territories. Use cross-country routes whenever practicable. They are desirable since they minimize interruptions resulting from friendly traffic, aerial bombardment, artillery fire, and mines. The construction chief is allowed considerable latitude in following the route indicated by the signal or communication officer, so that he may make changes in the event of unforeseen conditions. *A reconnaissance of the route by the construction chief before the wire lines are laid is essential.*

Caution: When laying wire along roads or cross-country in recently captured areas, be especially careful to safeguard against mines and booby traps. Use mine detector equipment in mined areas.

c. Maintenance. When planning wire lines, consider future maintenance problems. Whenever practicable, avoid main traffic routes, shelled areas, and

areas over which tanks or tractors are likely to pass. In most instances, maintenance can be facilitated by using a minimum number of routes. However, a small number of routes tends to increase the vulnerability of the lines, and complete interruption of wire communication may result unless each route is well chosen. The route or routes should, whenever possible, provide cover from hostile observation and fire, thus minimizing the hazard to men building or maintaining the line.

25. CONSTRUCTION ORDERS. **a.** The construction chief is given orders prescribing the number of circuits to be installed, the priority of installation, the time at which each of the various circuits must be completed, and the action to be taken upon the completion of the installation. The construction chief should receive or obtain the following decriptive information about each circuit to be laid:

(1) Circuit number.
(2) Route.
(3) Whether a trunk or a local circuit.
(4) Whether a metallic or a ground return circuit.
(5) Type of wire.
(6) Switching centrals the circuit will connect and test stations through which it will pass (including the telephone directory names of the organizations served).
(7) Approximate length.
(8) Type of construction.
(9) Nature of roads and terrain.
(10) Precautions to avoid damage by friendly troops and transportation.

(11) Tests and reports required.

b. *The information in* **a** *above is best provided by a line route map and circuit diagram, supplemented by oral or written instructions from the signal or communication officer.* These instructions always include orders as to the disposition of the construction detail after the construction specified has been completed.

26. CONSTRUCTION CENTER. **a.** Construction centers are installations located near or in a command post area where trunk and long local wire lines converge for entrance to the telephone central. Crews can be dispatched from this point by the construction chief or wire chief, thus eliminating unnecessary traffic in the command post area. Construction centers should be located at some distance, usually several hundred yards, from the command post switchboard. Testing equipment is installed at construction centers in order that maintenance personnel may terminate and test wire lines under construction, make routine tests on working lines, and make fault-locating tests on lines that are in trouble. These tests can be made at the construction center without interfering with the switchboard operators. At corps and higher headquarters it may be necessary, depending upon local circumstances, to have all testing equipment located nearer the command post switchboard, in which case the construction center may become only a test station.

b. The amount of equipment at a construction center may range from a terminal strip and telephone with test leads to a terminal frame, a test switchboard, and one or more test sets. Use standard equip-

ment whenever possible for establishing a construction center. However, varying situations may demand the full use of standard equipment or its equivalent. The equipment should be installed in such a way that it can be removed or disassembled readily. Figure 69 shows a suggested equipment lay-out for a construction center and associated test equipment installed in a 1-ton trailer.

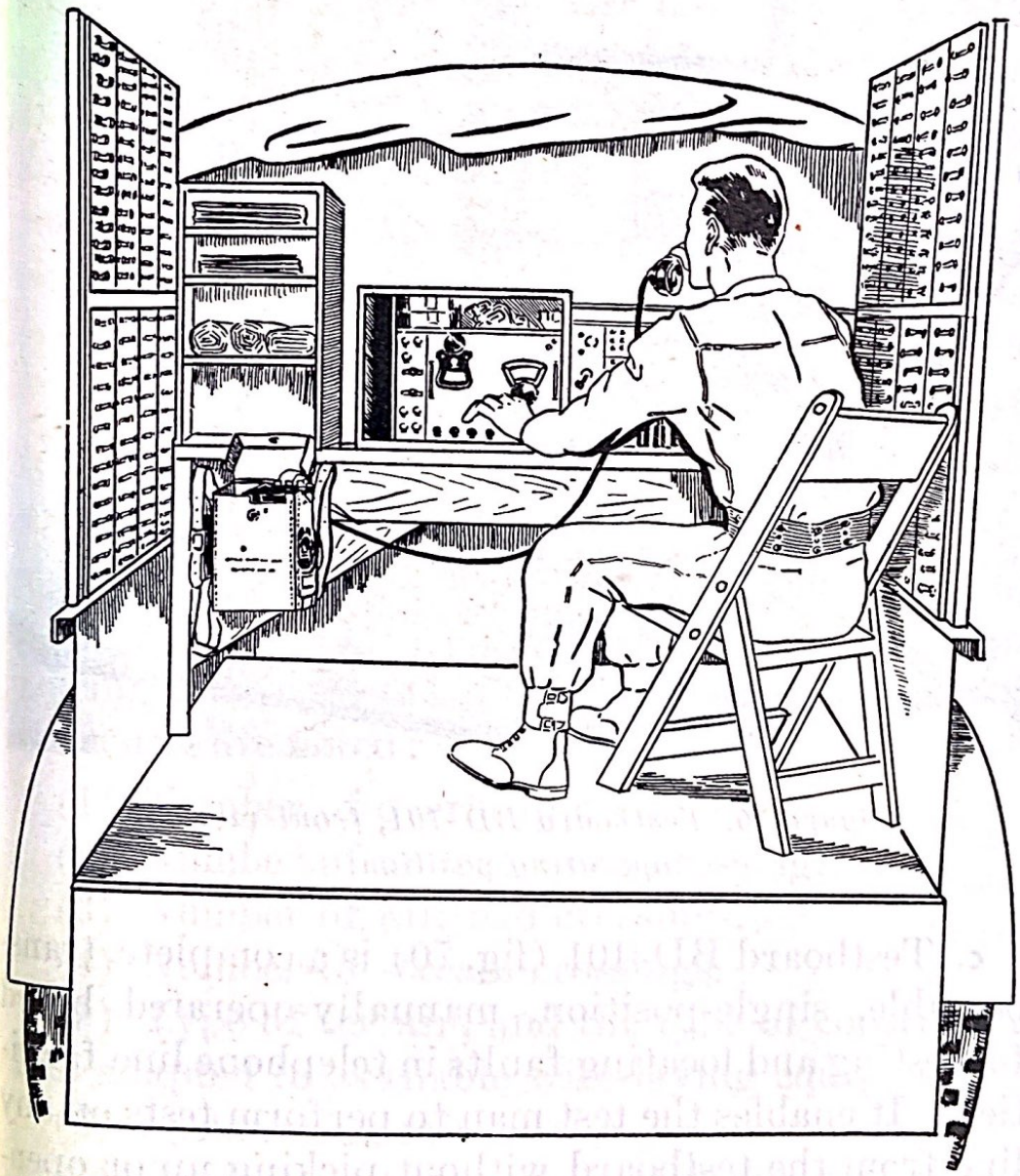


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Figure 69. Suggested equipment layout for a construction center.

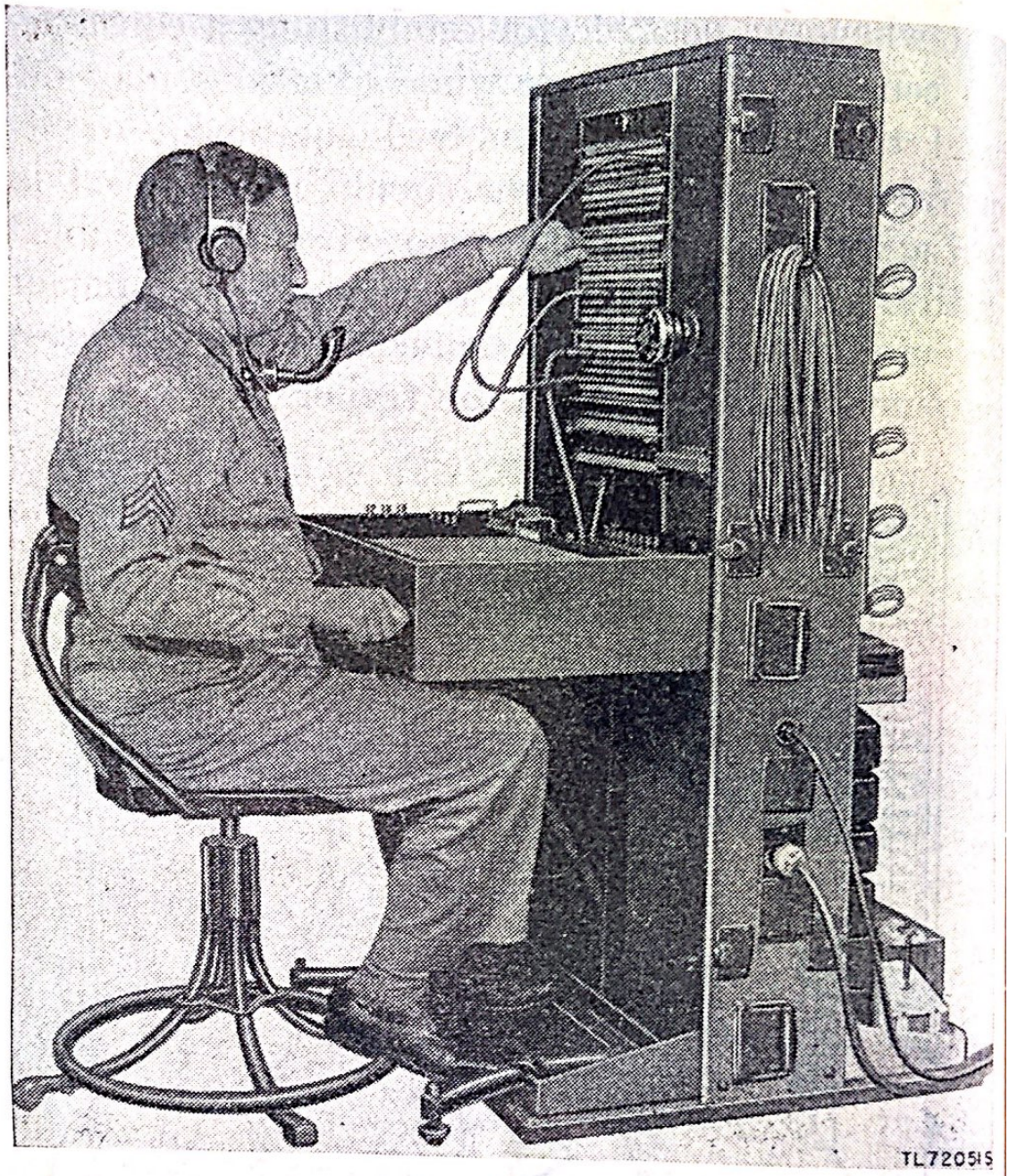

Figure 70. Testboard BD–101, front view, in operating position.

c. Testboard BD–101 (fig. 70) is a complete, transportable, single-position, manually-operated board for testing and locating faults in telephone line facilities. It enables the test man to perform tests on any line from the testboard without picking up or opening the line at the distributing frame. Each testboard consists of a jack field, a volt-milliammeter,

and telephone and testing equipment terminating in test cords. Means are provided for patching between line and drop equipment to restore service quickly on faulty circuits and also for providing phantom and simplex circuits. The testboard attendant may ring, talk, monitor, dial, and receive or originate calls on any line or trunk, thereby performing the same functions as the switchboard operator, when using the test cords in conjunction with the jack-ended equipment. The volt-milliammeter test circuit is capable of detecting shorts or crosses, grounds, and opens. It enables the testboard attendant to make current and resistance measurements. The capacitance-resistance bridge consists of a slide-wire type of d-c resistance bridge and a 20-cycle a-c insulation resistance for locating grounds, short circuits, crosses, and open circuits. For further details, see TM 11–2062 (when published).

27. PROCEDURE IN LAYING FIELD WIRE. **a.** Before starting the construction, the construction chief makes a personal reconnaissance of available routes. During this reconnaissance the following features of the routes are noted:

(1) Number of overhead crossings.
(2) Number of underground crossings.
(3) Number of railroad crossings.
(4) Number of stream crossings.
(5) Type of terrain, and the type of construction best adapted to available wire-laying equipment.
(6) Distances in miles.
(7) Concealment for wire parties during construction and subsequent maintenance.
(8) Any obstacles to maintenance.

(9) Alternate routes to avoid gassed, shelled, o
mined areas, or other unfavorable conditions.

b. The next step is to select and mark clearly on a
map the exact route along which the wire is to be laid
Select a route that meets the requirements of the tac-
tical situation and offers the least difficulty to con-
struction and maintenance.

c. *Test the wire for the circuits before starting, to insure the continuity of each reel.* Reels of wire that do not show a continuous circuit when tested are not used until the wire has been serviced (par. 85).

d. At the starting point, tag the free end of the wire with the circuit designation (par. 18). Place this tag 1 foot from the end of the wire.

e. Leave enough wire at the free end to reach the switchboard terminal strip or other installation, and tie the wire in to some fixed object.

f. Connect the free end of the wire to the construction center terminal strip, if installed; to the switchboard terminal strip; or to a Telephone EE–8–( ).

g. The construction chief determines the detailed route (**b** above) and directs the laying of wire. The general route prescribed by the signal or communication officer is followed (par. 24). After each splice is completed test back to the starting point from the far side of the splice in order to insure continuity of the circuit. Test clip pinholes are undesirable in the wire insulation; avoid them by making the test on the bare wires from the far side of the splice before taping is started. Be careful not to cause circuit trouble during the taping process. When connections are made at terminal strips make a test from the far side of the connection back to the starting point.

h. When the wire has been laid to the designated point, tie it in and tag it. Leave the free end with sufficient slack to run to the switchboard terminal strip. Test the circuit. The operating detail then connects it to the switchboard terminal strip or to an instrument. The construction chief calls back over the completed circuit to report the installation. This call is placed through the switchboard, or other instrument, if installed, so that any fault in the terminal connections may be discovered and corrected before the circuit is reported.

i. Should the wire be laid to any locations where a switching central is to be installed but where the operating detail or the equipment for the installation has not yet arrived, the construction chief calls back over the circuit in order to verify that he is at the right location and to ask for instructions. In the absence of other instructions, the construction chief leaves a member of the construction detail at the wire terminal with a telephone connected to one circuit. This man informs the arriving personnel of the location of the circuits and assists in making the terminal connections. After the terminal apparatus has been connected, he makes a test back and reports over each circuit. Sufficient slack is left at these terminals to permit extending the circuits to the probable location of the telephone central.

28. TEST STATIONS. Test stations may be installed on a wire line to facilitate the testing and rearranging of circuits. They may be located at points where circuits diverge, at the end of a wire line that does not terminate in a switchboard, near points where circuits are most exposed to damage, at probable fu-

ture locations of command posts, or at other convenient points on the line. If a command post is established where a test station has been installed previously, the test station can be converted easily into a telephone central. Usually test stations are given a geographic designation; for example, Jones Farm Test.

29. CONSTRUCTION AND REMOVAL OF TEST STATIONS. a. Construction. The site selected for a test station should afford cover from hostile observation and fire and protection from friendly troop movements. It should be readily accessible for testing. A test station consists of one or more terminal strips fastened to a support, such as a tree or fence post. The wire circuits are tagged and tied in before being connected to the binding posts. When two circuits are connected together at a test station, they are attached to corresponding binding posts on opposite sides of the terminal strip (fig. 71). Always start at

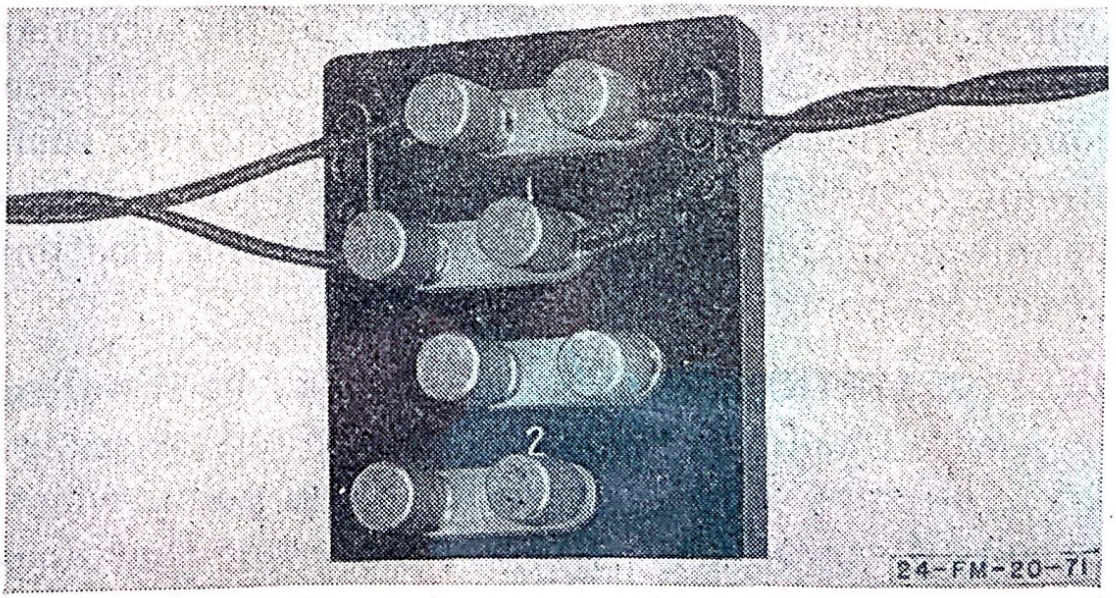

Figure 71. Test station constructed during initial installation of wire lines.

the top of the terminal strip to connect paired circuits. A telephone or other suitable instrument may be connected to the designated test circuits as prescribed in paragraph 82. A test station may be installed after initial installation of wire lines without interrupting any conversation on the circuit. This is done by the following steps: pull in the desired slack and tie in near the terminal strip; strip the insulation from each wire to permit connections to binding posts on opposite sides of the terminal strip (fig. 72). Other circuits are connected to the test point terminal strip in the same manner. The circuits are connected (in numerical order) beginning at the top with the lowest numbered circuit. Cut out loop to complete operation.

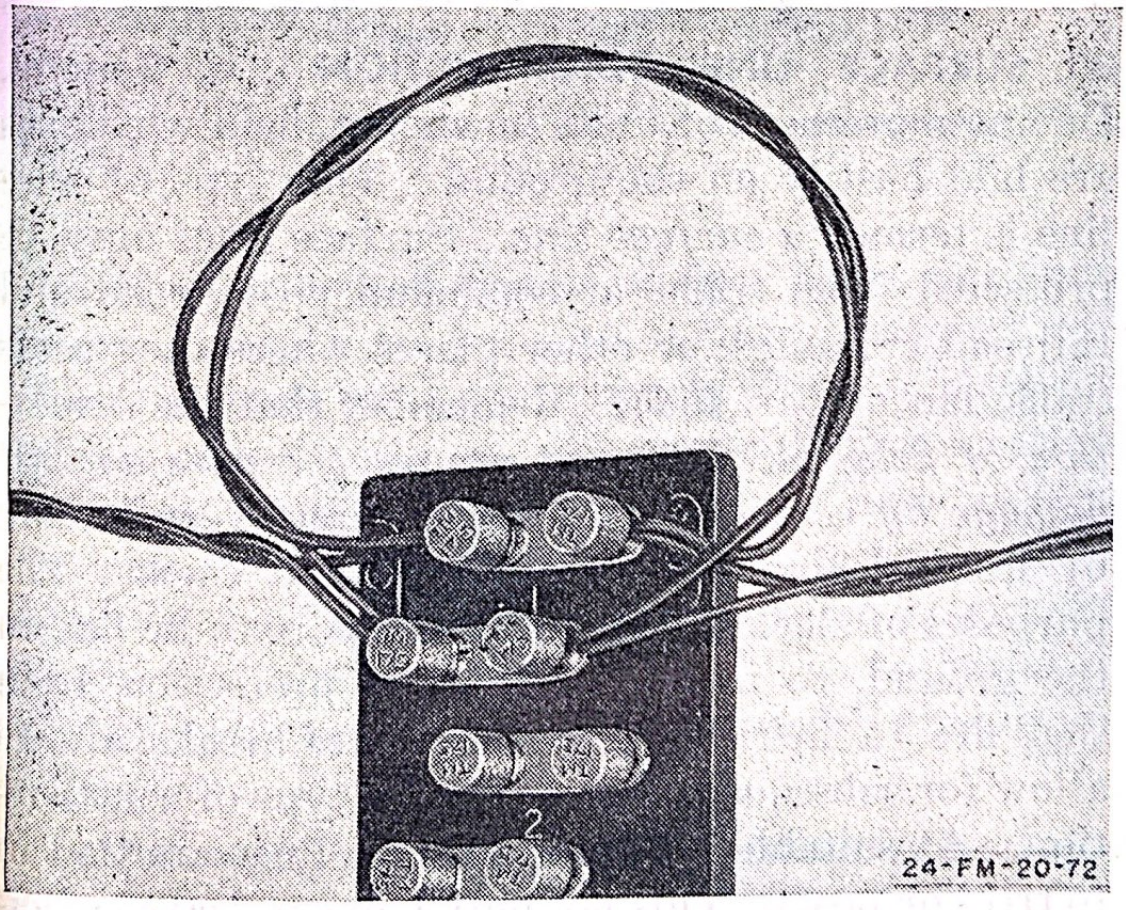

Figure 72. Test station being constructed after initial installation of wire lines.

b. Removal. When a test station is to be abandoned, the usual practice is to leave the terminal strip connected, although it may be removed and the circuits spliced through. Before removing any circuit from the strip, first listen in on the circuit to determine that it is not in use; then call on the circuit and notify the switchboard operator that the test station is to be removed and the circuits spliced through. When this has been done, take two wires that are connected together by the terminal strip, remove them from the binding posts, and splice them together. Then splice the other wires of the pair. Remove the other circuits from the strip and splice them in a like manner. As the work on any circuit is completed, check it in the same manner as for other splices.

30. SURFACE LINE CONSTRUCTION. a. General. During movement of units in combat, field wire lines are laid hastily on the ground. This type of wire line is termed *a surface line.* Surface lines must be protected from traffic at command posts, road and railroad crossings, or other places where they cross traffic lanes (par. 45**d**). Remember that the *insulation of field wire will not protect the wire against damage by vehicles.* Lay surface lines very loosely by leaving abundant, well-distributed slack. The purposes of slack are to enable the wire to lie flat on the ground, to provide incidental protection from shell fire, to facilitate the repairing of breaks, and to allow for subsequent changes in the type of construction. At suitable intervals, surface lines are tied in to trees or posts. This not only helps to leave sufficient slack but also prevents passing troops and

vehicles from pulling the wire into traffic lanes. Make such ties to trees or posts at ground level (fig. 73). When surface lines are routed along a road, the wires *must* be kept well off the traffic lane. If the road curves, and it is practicable to do so, route the line along the inside edge of the road; otherwise, it becomes necessary to make many ties on the outside edge (fig. 74).

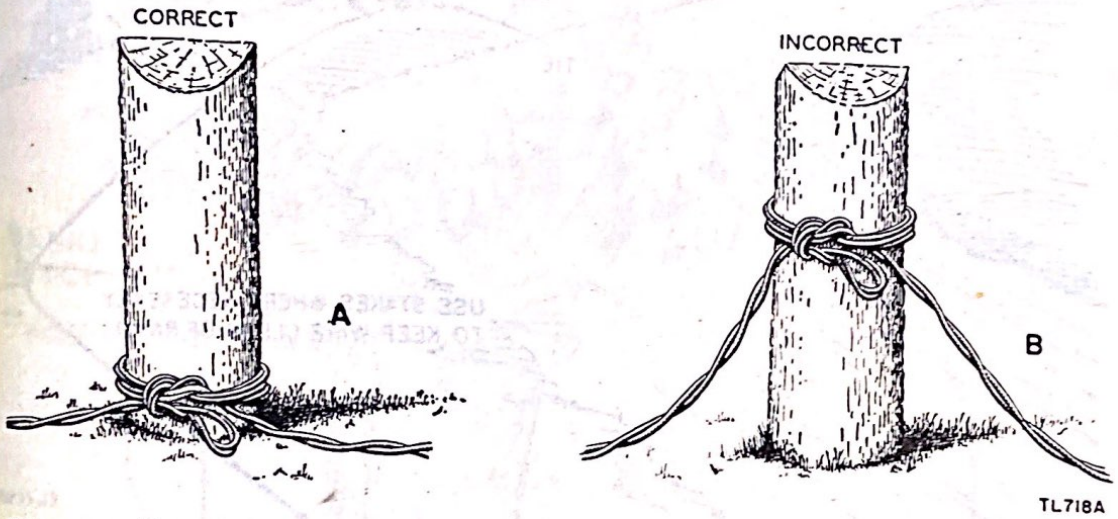

Figure 73. Method of tying wire with a square knot tie at ground level.

b. Connections between surface lines and pole lines. Connections between surface lines and pole lines are made most conveniently at established terminals or test stations. Whenever such connections are made, tie the surface line securely and tag it at the base of the pole at which the connection is made; again tie the line just above the cross arm or terminal where the lines connect. Connections to aerial or buried cables are made only at standard cable terminals.

c. Advantages. The principal advantages of surface lines are—

(1) They require minimum time for installation.

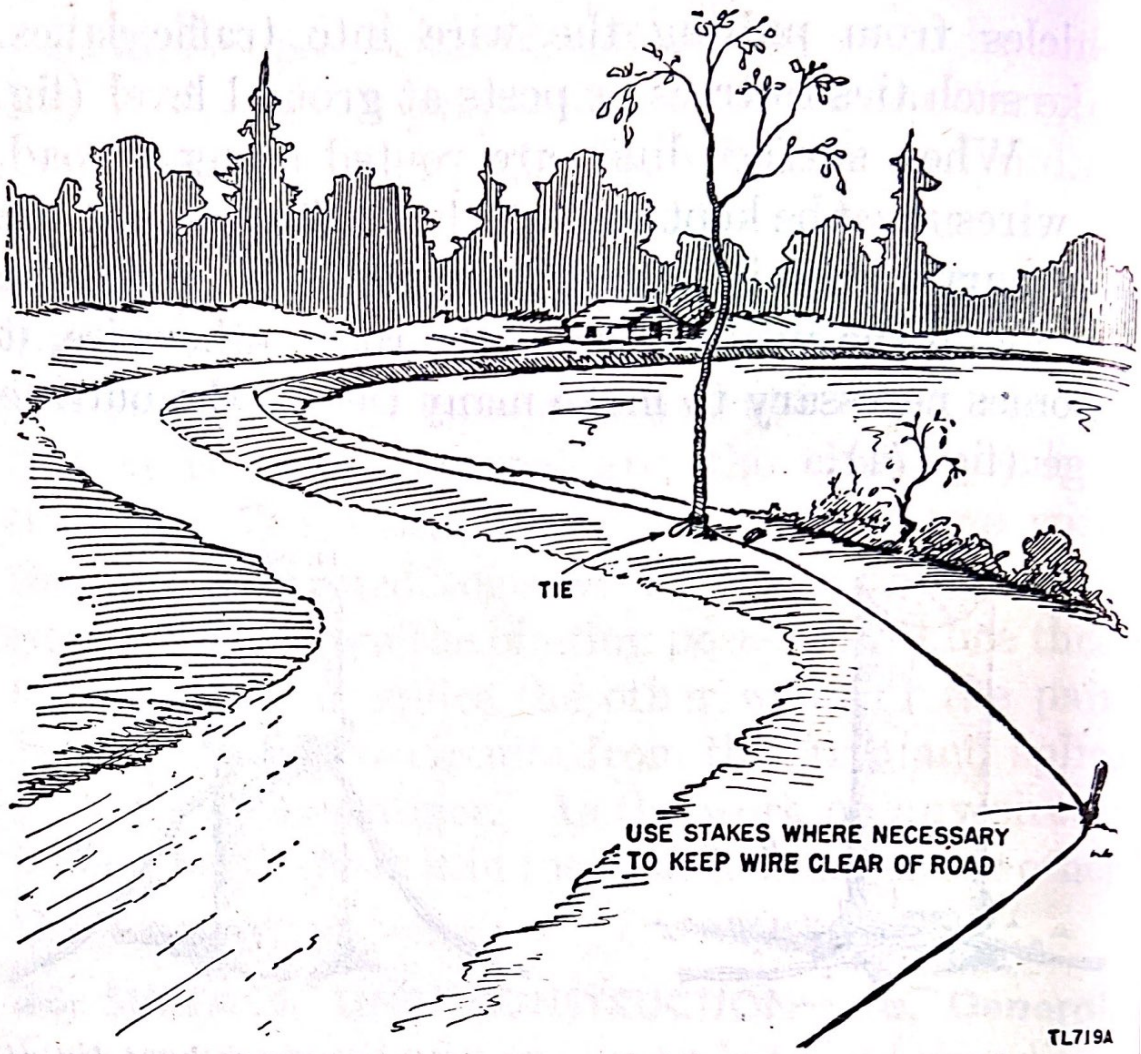

Figure 74. Method of tying wire along curve in road.

(2) When loosely laid, they are less vulnerable to artillery fire than other types of construction.

d. Disadvantages. The main disadvantages of surface lines are—

(1) They may become unserviceable in wet weather as a result of leakage to ground.

(2) They often are broken by passing troops and vehicles.

31. OVERHEAD CONSTRUCTION. a. General. Field wire lines should be placed overhead near command posts, congested troop areas, along roadways at points where traffic is likely to be diverted from the road, and at main and secondary road crossings where

no practical surface method is available (par. 32). Trees and existing poles are the most desirable supporting structures; use them whenever they are available. Use standard field wire ties (par. 17) to attach wires. The type of tie used depends on span lengths and local climatic conditions. At junctions between overhead and surface line construction, tie the wires securely to the bottom of the support and tag them (fig. 75). In general, install test stations at junc-

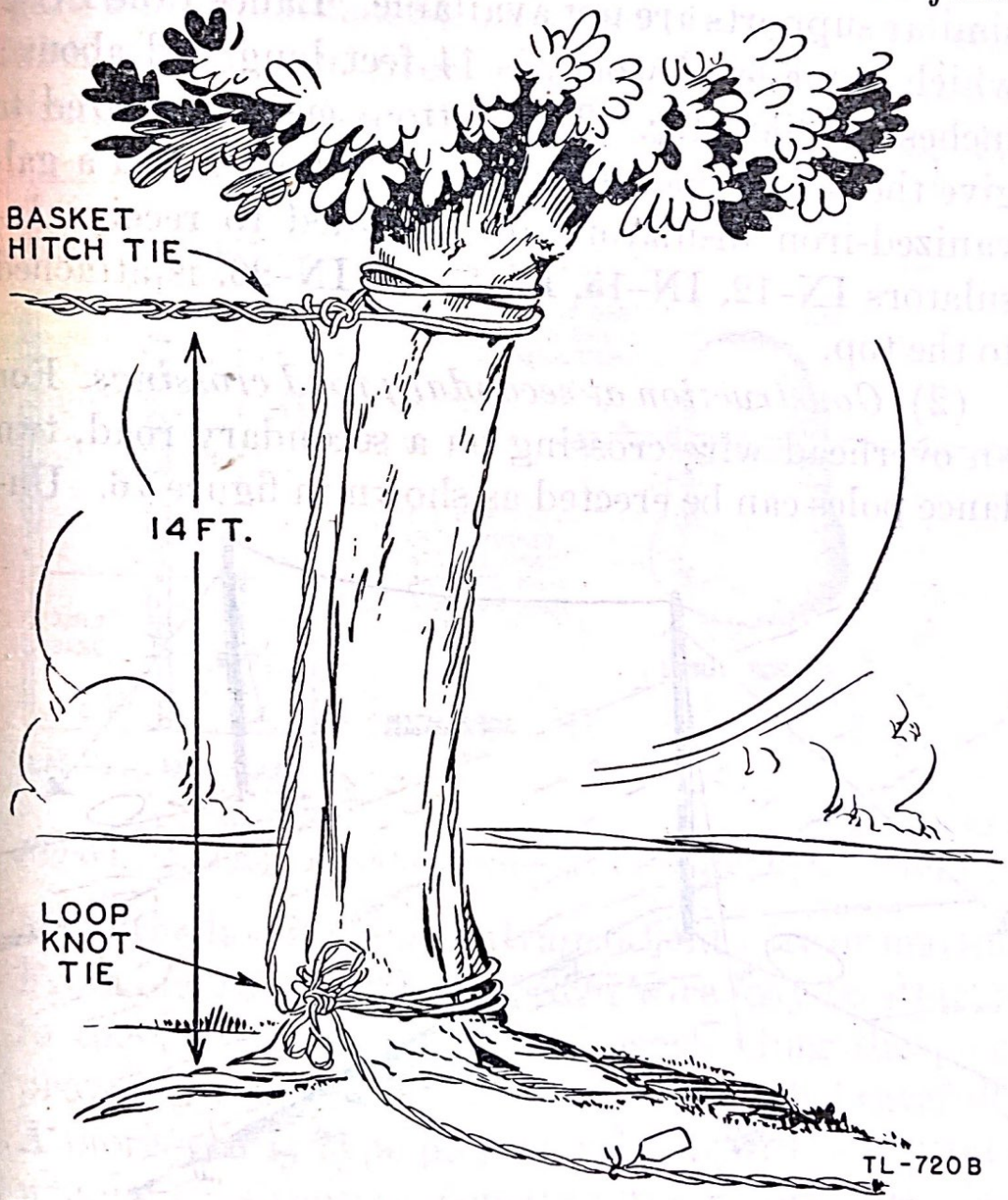

Figure 75. Method of tying wire at junction of surface line with overhead construction.

tions of long overhead lines with other types of construction. When field wire is placed on commercial or other poles carrying bare wire on cross arms or brackets, place the field wire below the lowest bare wire. Never place field wire so that it will swing into or come in contact with bare wire.

b. Lance pole construction. (1) *General.* Lance poles provide a convenient method for supporting field wire lines where trees, telephone poles, or other similar supports are not available. Lance Pole PO–2, which is made of wood, is 14 feet long and about 2 inches in diameter. The bottom end is tapered to give the pole a good bearing in the earth, and a galvanized-iron insulator pin, threaded to receive Insulators IN–12, IN–15, IN–25, or IN–26, is attached to the top.

(2) *Construction at secondary road crossings.* For an overhead wire crossing on a secondary road, two lance poles can be erected as shown in figure 76. Un-

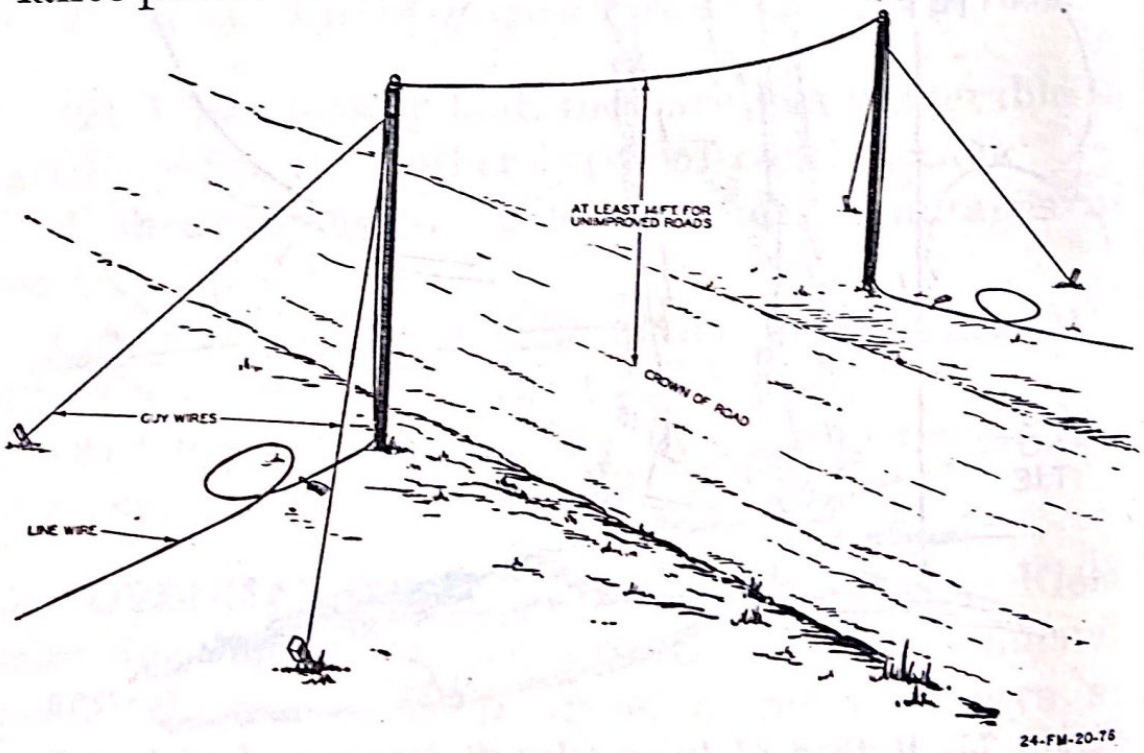

Figure 76. Crossing secondary road using lance poles.

less the shoulders of the road are higher than the crown, the minimum clearance of 14 feet cannot be obtained and the lance poles must be lashed as explained in (3) below. In areas where saplings or bamboo is available, it is advisable to utilize these resources and conserve the supply of lance poles.

(3) *Construction at main road crossings.* For a wire crossing over the main road, one lance pole will not provide the necessary clearance of 18 feet. To gain additional height, lash two lance poles together with a minimum overlap of 5 feet. If additional strength is required, use two base poles (A, fig. 77).

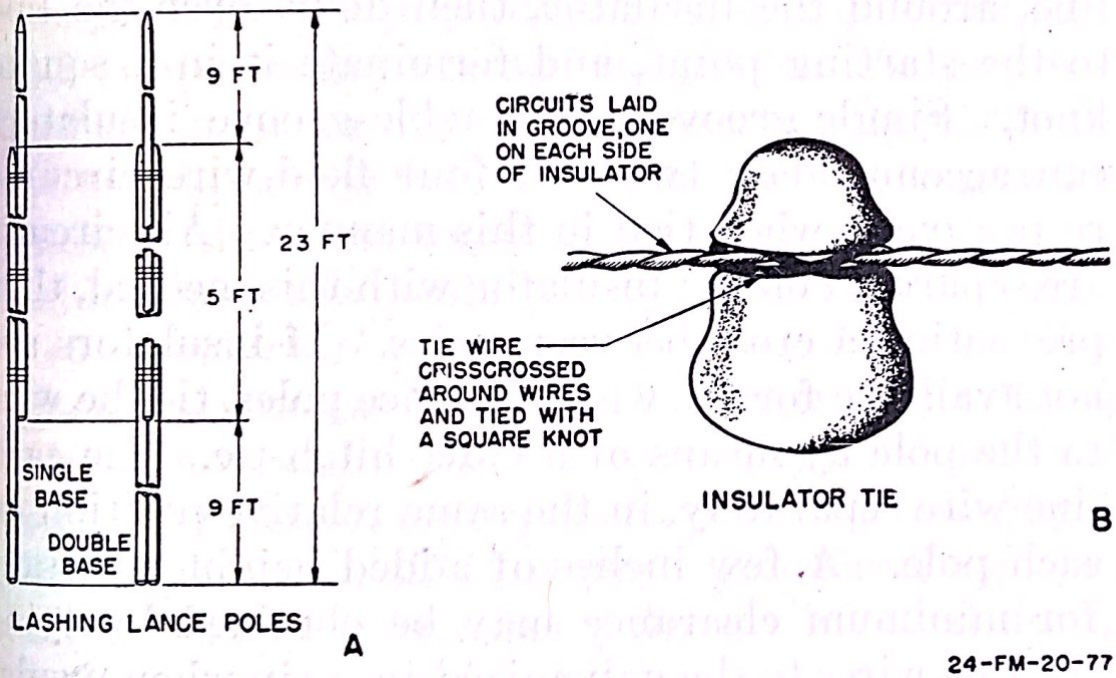

Figure 77. (A), Lashing lance poles and (B) insulator tie.

Make the lashing with salvaged field wire or marline. From one to four pairs of field wire may be attached to these lance poles without overloading the poles, provided that the line has been constructed carefully. A more sturdy type of construction will be desirable where the situation demands that more than four circuits cross a road or where a long span is necessary.

Under these conditions, follow the detailed instructions given in TM 11–369 for overhead construction, using 4 by 4 sawed lumber.

(4) *Tying.* When insulators are used on the lance poles and climatic conditions will not affect the insulation on the field wire, the clove hitch tie may be used to attach the line wires to the insulators. A crisscross type of tie (B, fig. 77) is recommended when climatic conditions will affect the insulation and when the line is expected to remain in place for some time. To make this tie, pass a piece of salvage field wire under the line wire, cross it up over the line, around the insulator, then down over the line to the starting point, and terminate it in a square knot. Single-groove and double-groove insulators can accommodate two and four field-wire circuits, respectively, when tied in this manner. All circuits are separated on the insulator with this method, thus preventing a cross between pairs. If insulators are not available for use with the lance poles, tie the wire to the pole by means of a clove-hitch tie. Tie each line wire separately, in the same relative position on each pole. A few inches of added height necessary for minimum clearance may be obtained by tying the line wires to the galvanized-iron tip when insulators are not available and when one or two circuits are being installed. However, first wrap this tip with two layers of friction tape to prevent the threads from cutting through the wire insulation. Tie the line guy and wire to the poles while they are lying on the ground, regardless of what type of tie is used. The poles with the wires attached are then erected and guyed in place.

(5) *Guying.* Lance poles require more guying than any other type of overhead construction. Where possible, lash lance poles to solid posts or stumps. If there are no supports of this kind available, side-guy every lance pole on both sides of the line, with the exception of corner poles, where only one guy, placed so that it bisects the angle of the corner resisting the pull, is needed to hold the pole erect. Salvage lengths of field wire make the most suitable material for guy wires. Generally, a piece of wire approximately 40 feet long, tied in the center, with a clove hitch near the top of the lance pole, will be long enough. Tie the guy wires to stakes or other suitable supports and place them so that the guy will extend out at an angle of approximately 45°. Do not use supported field wire line circuits to guy the poles, as this puts unnecessary strain on the wires and increases the possibility of trouble in the line.

(6) *Construction of straight sections of line.* When it is necessary to install field wire lines on lance poles in a straight line, the span lengths should not exceed 100 feet, and every tenth pole should be guyed four ways. This will prevent the entire line from falling if any of the other poles are knocked down. If windstorms, snow, or sleet is expected, reduce the distances between the poles.

32. ROAD CROSSING. a. Where a road crossing is necessary, field wire line should cross through a culvert, if possible. Pass the wires through the culvert, tag them, and tie them at the entrance and exit to prevent contact with the water (fig. 78). Be especially careful during floods. If the wires touch the

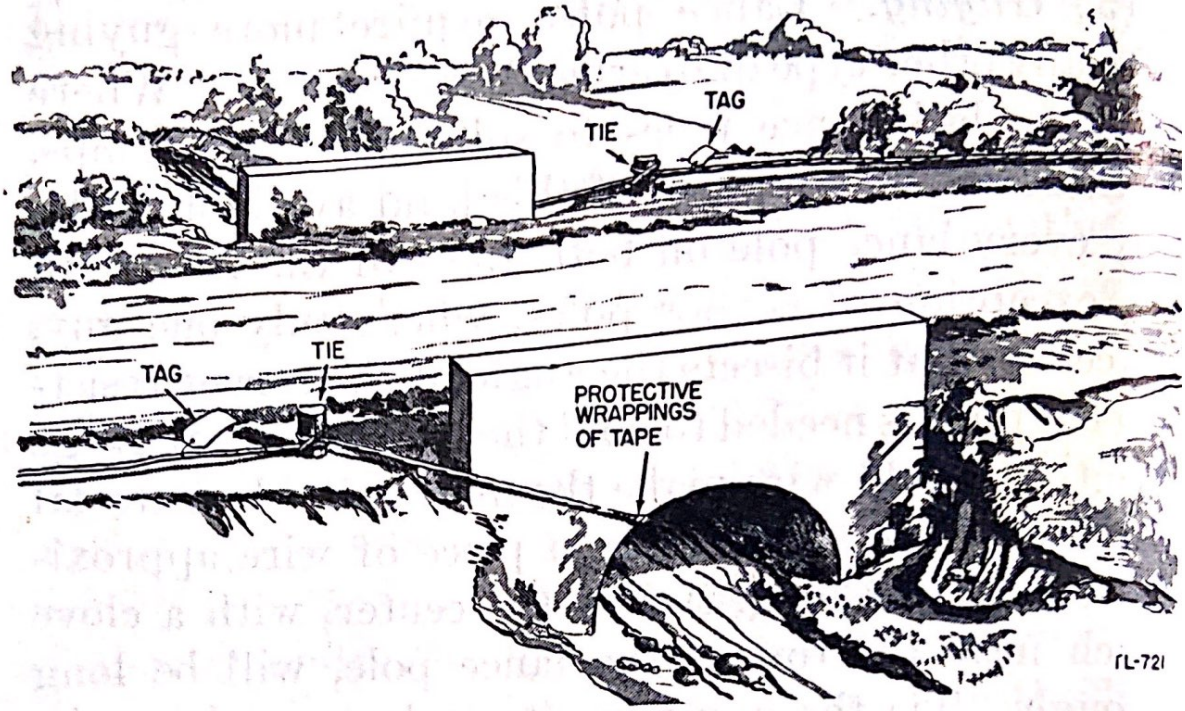

Figure 78. Wire crossing road through culvert.

edge of the culvert, wrap the wires at the point of contact to prevent damage to the insulation.

b. Wires that cross roads overhead (fig. 79) must clear the crown of main traffic arteries and paved roads by at least 18 feet and of other roads by at least 14 feet. When a surface line crosses a road on poles or other objects, tie the wire at the base and at the top of the object on each side of the road and tag it at the base. The strain which occurs along the line is carried by the tie at the base.

c. If neither of the preceding methods can be used, bury the wires in a trench (fig. 80) which crosses the road at a right angle. Lay the wires snug, tag them, and tie them to a stake at each end of the trench to prevent their being pulled out. Leave sufficient amount of slack wire at one side of the road to permit replacement of the section under the road, if the section should become worn or water-soaked. *The trench should never be less than 6 inches deep;*

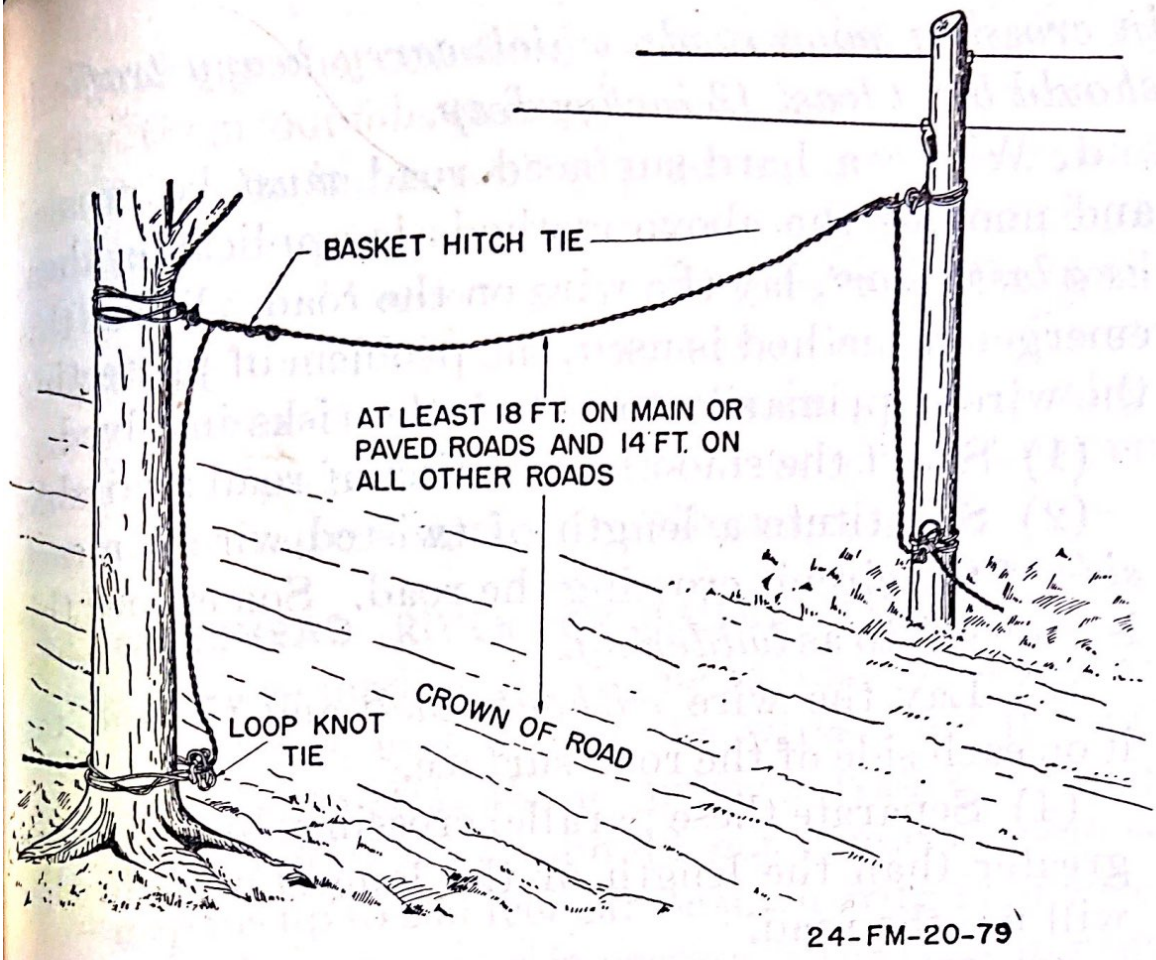

Figure 79. Wire crossing road overhead.

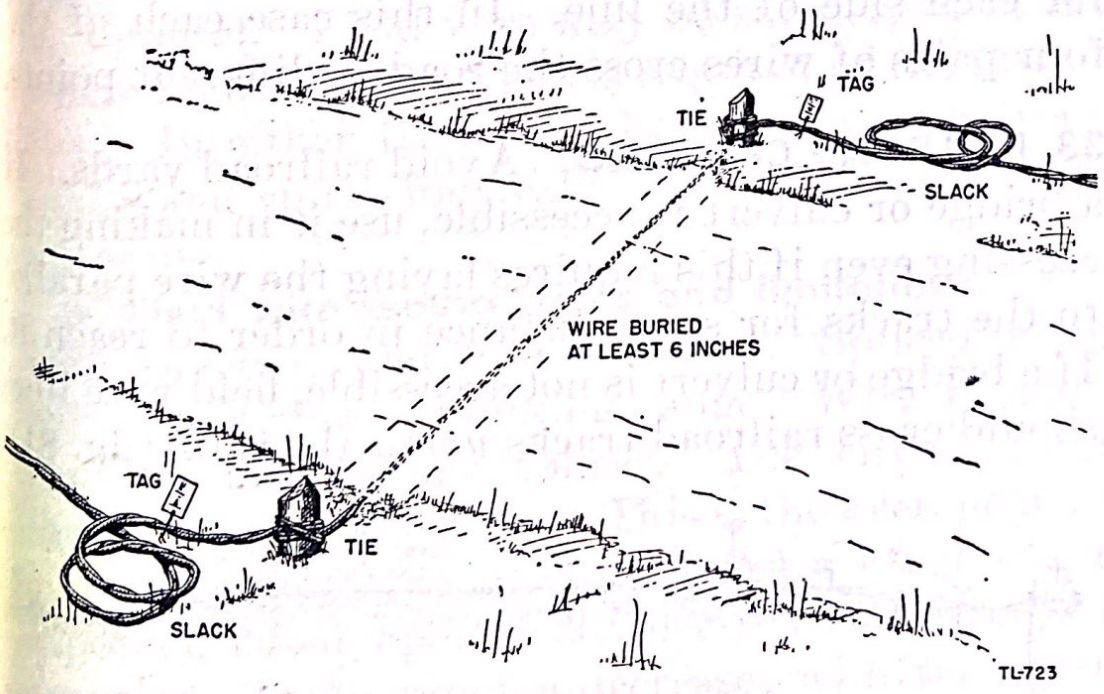

Figure 80. Wire crossing in trench under road.

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in crossing poor roads which carry heavy traffic i
should be at least 12 inches deep.

d. Where a hard-surfaced road *must* be crosse
and none of the above methods is applicable, then
as a last resort, lay the wire on the road. When thi
emergency method is used, the problem of protectin
the wire is primarily to reduce the risks involved.

(1) Select the smoothest section of road available

(2) Substitute a length of twisted wire for each
side of the circuit crossing the road. Sometimes this
is referred to as *laddering*.

(3) Lay the wire *without slack* and tie and tag
it on each side of the road surface.

(4) Separate these parallel crossings by a distance
greater than the length of the longest vehicle that
will use the road.

(5) Keep an exact record of this type of crossing
and inspect it frequently.

(6) It may be necessary to use two twisted pairs
for each side of the line. In this case each of the
four pairs of wires cross the road at different points

33. RAILROAD CROSSING. Avoid railroad yards. If
a bridge or culvert is accessible, use it in making the
crossing even if this requires laying the wire parallel
to the tracks for some distance in order to reach it.
If a bridge or culvert is not accessible, field wire lines
should cross railroad tracks *under* the rails (fig. 81).

Figure 81. Wire crossing under railroad track.

In making the crossing, pull the wires tight and bury them outside the rails to a point beyond the shoulders or improved strip along the tracks; then secure them on both sides to prevent them from being pulled out and becoming a hazard to trainmen walking along the tracks. Field wire lines should *never cross railroads overhead* (except in jungles, where wire *must* go overhead) because overhead lines endanger trainmen on top of railroad cars.

34. OVERHEAD RIVER CROSSING. Small stream crossings are made in the same manner as overhead road crossings, except that the wires need be only high enough to clear the waterborne traffic. A span of more than 150 feet should not contain a splice. Long spans up to 250 feet can be made with field wire, but special construction is necessary for resisting the strain. (See TM 11–369.)

35. LAYING FIELD WIRE AND CABLE UNDER WATER.

a. General. Field wire may be submerged in cases where relatively short life is required of the installation. In either fresh or salt water, 5- and 10-pair cables and spiral-four cable are suitable for underwater use.

b. Field wire requirements and limitations. Wire with perfect insulation is necessary. Spliced-in wire will reduce effective talking range. Wire W–110–B may contain factory splices. The circuit length should not exceed 9 miles. This is the average maximum wire length over which talking range can be expected, based upon a 30-db circuit at voice frequencies. Talking range decreases with the age of the installation.

c. Preparing wire for laying. (1) *Splicing field wire.* Follow standard splicing instructions in paragraphs 15 and 16, substituting DR Tape TL–192 for Tape TL–94. If Tape TL–192 is not available and Tape TL–94 is used, apply rubber cement between the two layers of rubber tape. Extend tape to cover 1½ inches of wire insulation instead of normal one-half inch.

(2) *Splicing Wire WD–1 ( )/TT.* At a point 4 inches from the end of the conductor, score the insulation with a pair of sharp pliers or a sharp knife. Do not cut the conductor strands. Push the 4-inch length of insulation off the conductor except for approximately 1 inch to keep the conductor strands from spreading apart. Cut off the stripped insulation except for the short section left on the conductor. After the conductors have been spliced together, tape the splice with two layers of DR Tape TL–192 and two layers of friction tape as outlined for Wire W–110–B, except that the rubber tape should extend for at least 2 inches beyond the end of the original insulation. Be careful to apply the rubber tape with maximum tension because the rubber does not bond to the synthetic insulation. Satisfactory insulation depends on a tight mechanical grip on the insulation to exclude water.

(3) *Testing and replacements.* Before placing the wire in the laying vehicle make a continuity test. Also make continuity tests, from the end point to the starting point, after each length is added to the circuit. Replace faulty sections.

d. Cable requirements and limitations. Choice of proper cable will depend upon the number of circuits

required, the transmission requirements, and the availability. Cables that are properly spliced and installed under ordinary conditions usually last about 1 year. If installations are required for a longer period of time, use standard submarine cable. The length of underwater installations using standard tactical cable is limited only by transmission requirements. Loading other than that built into Cable Assembly CC–358 is not practical for use in such installations. Standard tactical cable may be laid to depths of at least one-half mile without harm if splices and connections are properly made. See TM 11–369 for additional data on cables.

Note.—Unless otherwise noted, the word "wire" appearing in the following text means field wire or rubber-covered cable.

e. Anchoring and reinforcing. Any of the wires discussed in **a** above are heavy enough to sink and are therefore suitable for direct laying in calm or deep water without an attached weight. Where the current is greater than 2 to 3 miles per hour or where there are breaking waves or tides, prevent any excessive motion of the wire by the addition of weights along the wire and by secure anchoring, thus minimizing abrasion.

(1) *Anchoring wire.* To prevent bowing out of the wire between anchorage points, distribute the extra weight along the wire length being reinforced by using Wire W–115 (6M messenger strand) to weight the wire. Tie the messenger strand and wire together at approximately 3-foot intervals by means of clove hitch and square knot ties made with short lengths of Wire W–110–B (fig. 82). Wire WS–3/U (2.2M messenger strand) or Wire W–90

(10M messenger strand) may also be used as rein forcing wire. However, Wire W–90 is heavier and harder to handle and Wire WS–3/U must be supplemented with additional weights applied at 10- to 20-foot intervals. The additional weight using Wire WS–3/U should amount to about one-quarter pound per foot of wire.

(2) *Anchoring messenger strand.* When messenger strand is used to reinforce wire the messenger

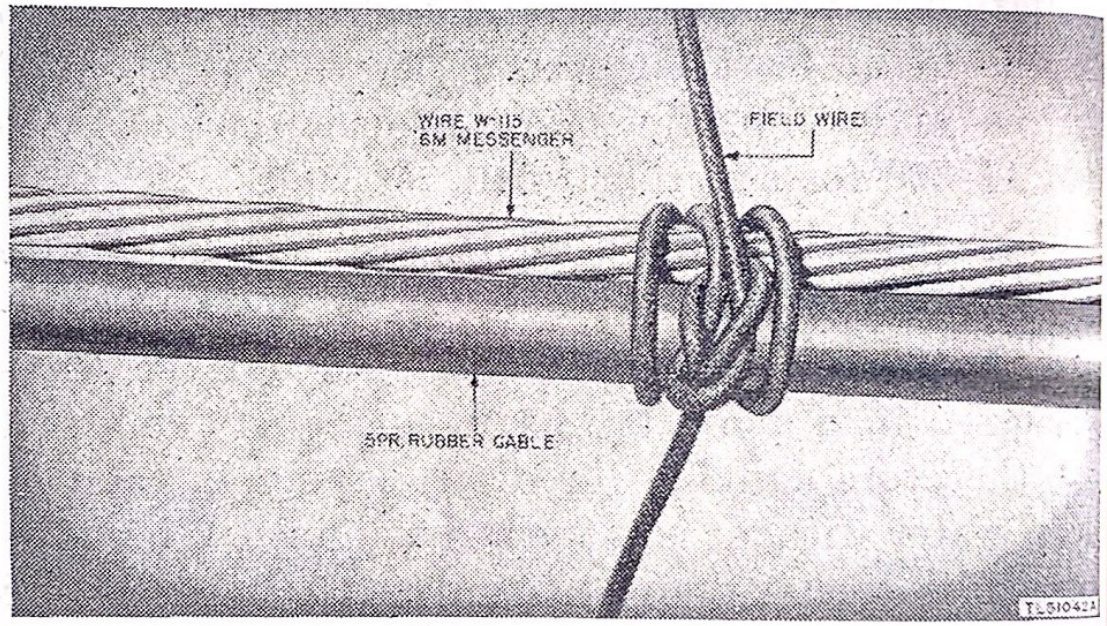


Figure 82. Messenger strand tied to wire for reinforcement

must be anchored securely at both ends. A loop for attachment purposes can be made in the end of the messenger with a three-bolt clamp.

(*a*) On a sand, mud, or coral beach, fasten the shore end of the messenger to a log buried at right angles to the direction of the wire. Place the log well above the highest point reached by the water at high tide (fig. 83).

(*b*) If the shore is rocky and rough, anchor the messenger by any suitable means (such as tying it to

a rock). If necessary, extend the wire far enough inshore to allow the use of a log anchor.

(*c*) When the shore approach is made over a bulkhead, obtain a long pole, such as might be made by lashing two lance poles together, and loop and fasten the messenger about 3 feet from the lower end of the pole. Drive the pole into the earth at the base of the bulkhead so that the messenger lies flat on the bottom (fig. 84). Lash the top of the pole securely to the top of the bulkhead and lash the wire to the pole at several points along its length.

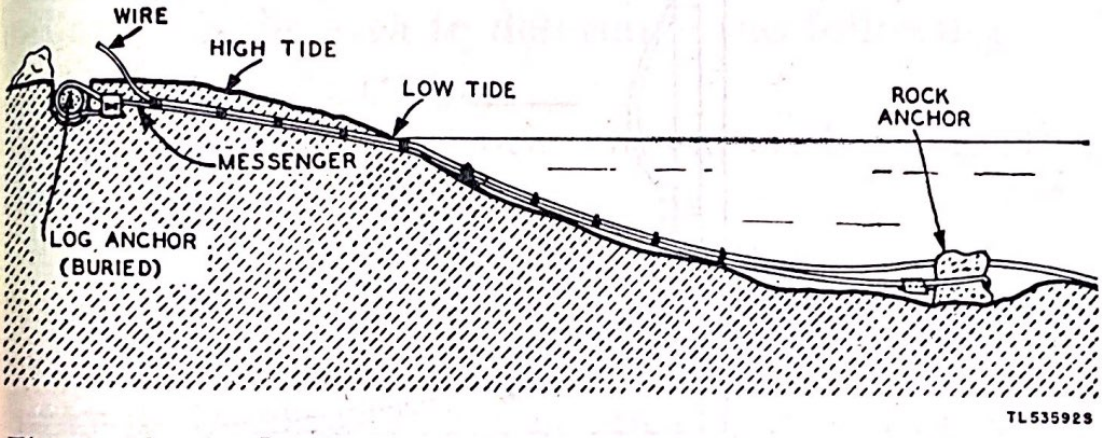


Figure 83. Anchoring and reinforcing shore approach, smooth beach

(*d*) When wire is laid over a sand, mud, or coral beach, bury the wire from the log anchor to the low-tide water level. This protects the wire from breakers and shore traffic.

(*e*) Fasten the seaward end of the messenger to at least a 100-pound stone or metal anchor. On unsheltered shore approaches subject to breakers of the open sea, the messenger should be long enough to permit placing this anchor in deep water (possibly 60 feet). If the shore approach is sheltered, the messenger should extend to the nearest point where the water has approximately the greatest depth. In any

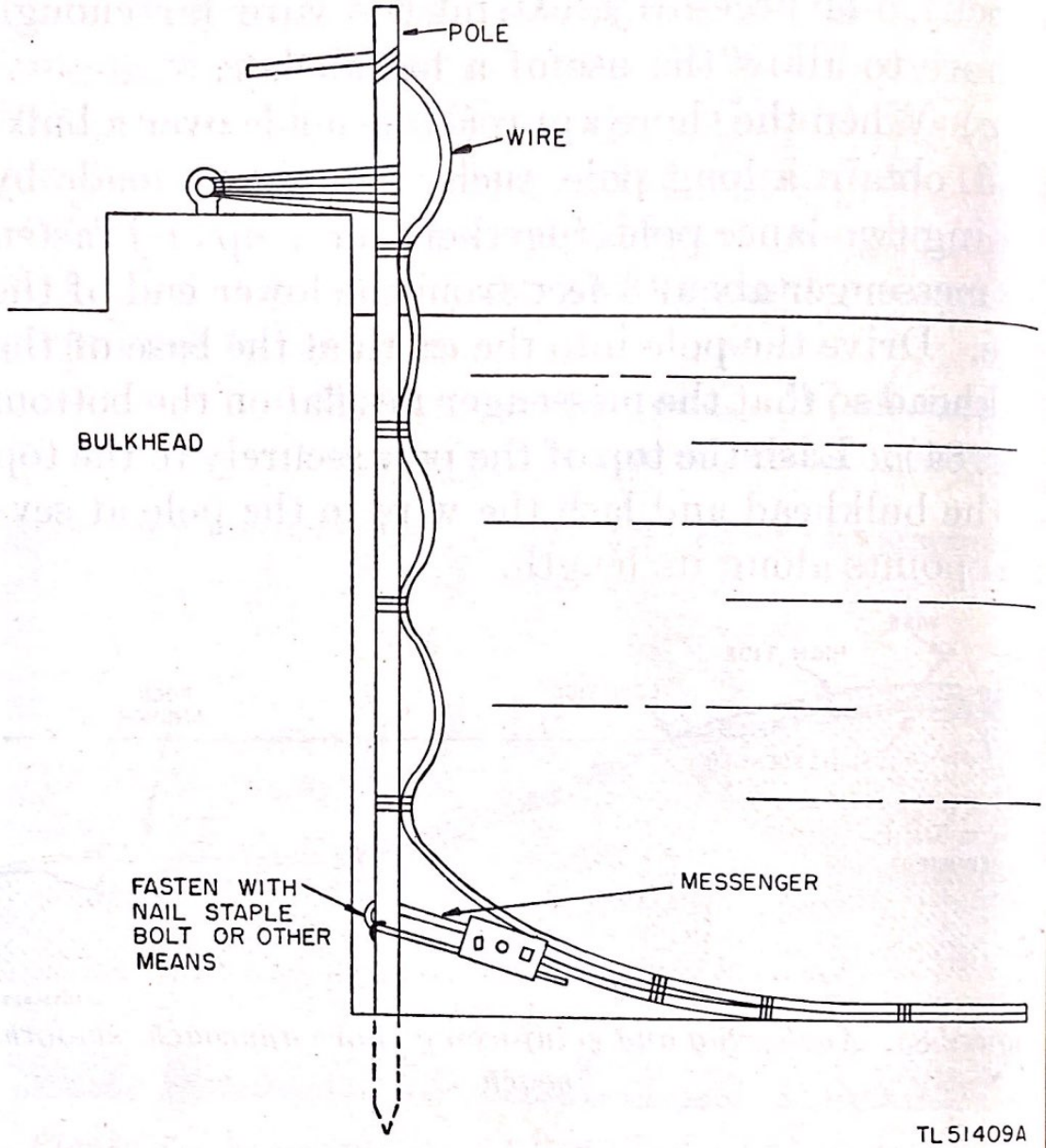


Figure 84. Anchoring and reinforcing shore approach, bulkhead.

case, the messenger reinforcement should extend beyond the point where the waves normally begin to break.

(*f*) When the wire is tied to the messenger, the distance between the last tie and the seaward anchor should be equal to or slightly greater than the maximum depth of water above the anchor. This makes it possible to raise the wire to the surface for inspection and repairs without raising the anchor, provided

the shore end of the wire is released from the long anchor (fig. 85).

f. Surveying wire-laying route. Before laying wire, survey the proposed route. Select beaches that will not be used for landing amphibious craft. If this is not possible, the points where the cable enters and leaves the water should be well marked by driving poles or piles with signs attached, indicating to approaching amphibious craft the presence of an underwater cable. Make depth soundings and study all hydrographic data. Consult reliable persons familiar with the area to determine the following:

(1) Length of route.

(2) Approximate depth encountered along the route.

(3) General character of the bottom.

(4) Shore line conditions (sandy beach, coral rocks, walls, etc.)

(5) Tidal rise and enough information to predict the times of low tides.

(6) Approximate current speeds.

(7) Whether shore line approaches are sheltered from, or exposed to, main waves and breakers from the open sea.

g. Suitability of military vehicle. Truck, amphibian, 2½-ton, 6 x 6 (Dukw), is a military vehicle well suited for laying wire. It is seaworthy and large enough to provide ample wire storage and working space. It need not be anchored off shore when making shore approaches. Cargo Carrier M–29C and truck amphibian, ¼-ton, 4 x 4, can be used for laying short lengths of wire in calm water with Reel Unit RL–31, or as auxiliary vehicles for making

shore approaches when a nonamphibious vehicle is used for the main wire laying.

h. Preparing vehicles for laying wire. Several methods are possible for laying wire and for storing the wire in the boat in preparation for laying.

(1) *Reel Unit RL–31.* Mount Reel Unit RL–31 on the afterdeck of the boat or amphibious vehicle. This is the most suitable method for laying short sections which do not involve splices.

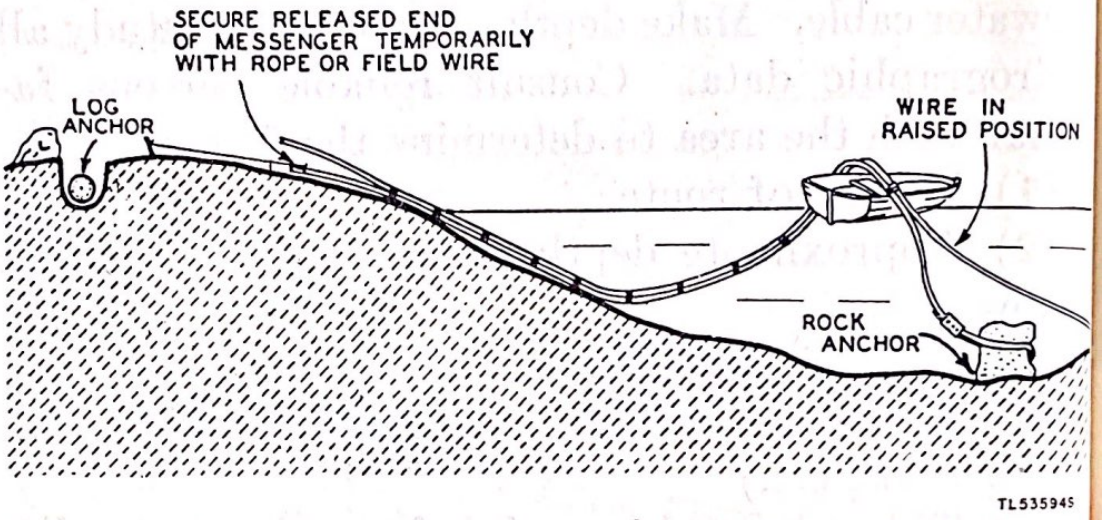


Figure 85. Raising cable for inspection, shore approach.

(2) *Figure-eight.* If fairly long wire sections must be laid, stow the prespliced wire in figure-eight form in the cockpit of a Dukw or other suitable vehicle (fig. 86). Avoid too high a hump where the wire crosses in the center of the figure-eight. Cross alternate layers at different points. Reel Unit RL–31 with an empty Reel DR–5 or DR–15 can be used to facilitate paying out over the stern. If a considerable distance must be traveled from the point of stowing to the water's edge, lash the wire temporarily in place with rope or field wire.

Note. Four or five men can stow cable at the rate of about 1 mile per hour. By using the figure-eight method, 4 or 5 miles of prespliced tactical cable can be used in a Dukw.

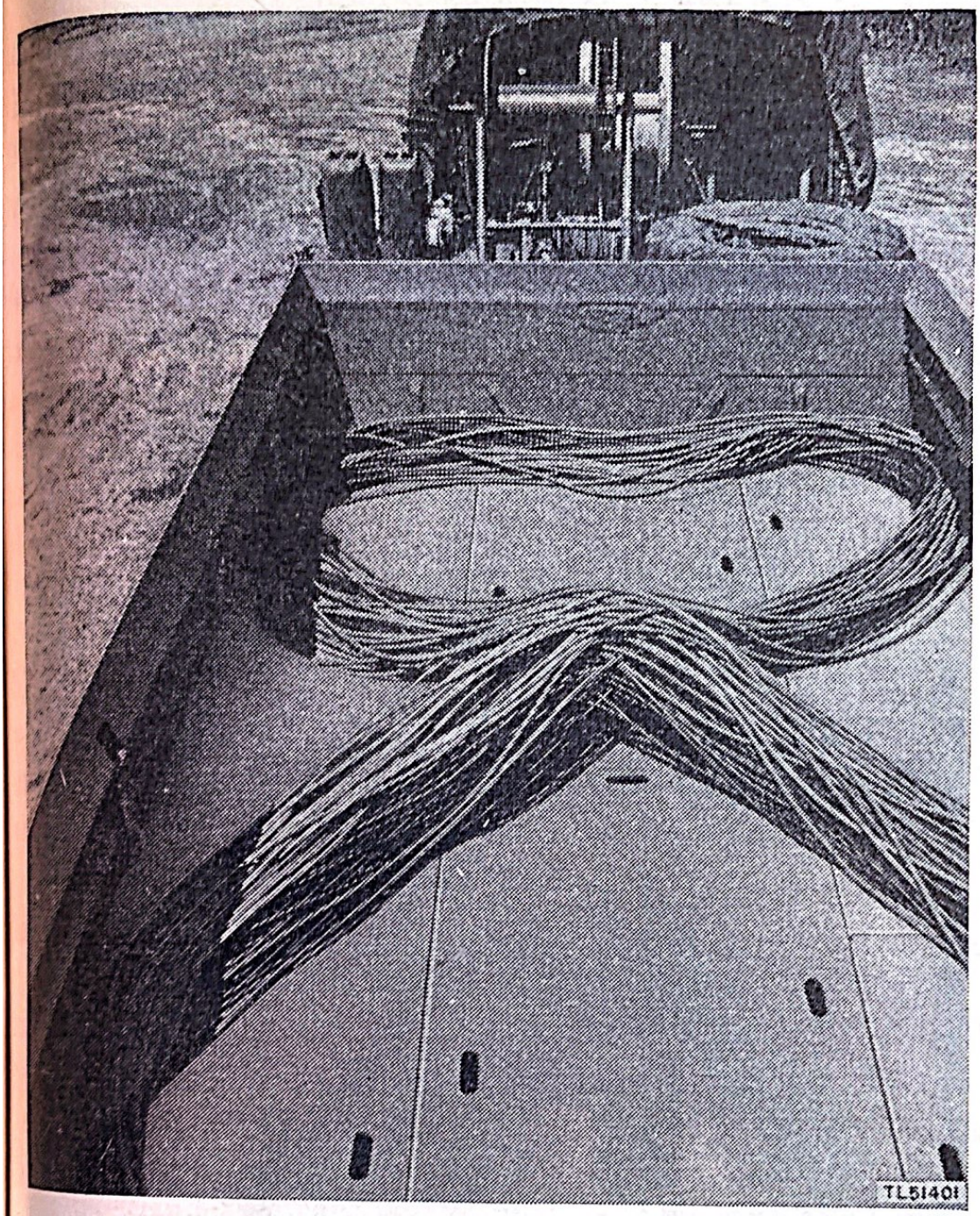


Figure 86. Wire stowed by figure-eight method.

(3) *Large jack-mounted reel.* A suitable military vehicle in which a large jack-mounted reel can be used is an amphibian, 2½-ton, 6 x 6 truck (Dukw). Jack and reel mounting arrangements are shown in figure 87.

i. Laying reinforced wire at starting point. Lay wire at low tide whenever possible. Local conditions

and available equipment may require spec
methods. Proceed as follows when the beach is o
sand, mud, or coral:

(1) Anchor the laying vehicle just off shore o
if amphibious, drive it up on the beach.

(2) Lay the required length of reinforcing mes
senger back and forth on the beach. Fasten one en

Figure 87. Jack mounted reel installed in truck.

to a log anchor which is buried at right angles to the direction in which the wire is to be laid, and fasten the other end to the rock anchor. Place the rock anchor aboard the laying vehicle.

(3) Lash the wire and messenger together at 3-foot intervals, using the clove hitch or square knot ties. Between the last tie and the rock anchor, leave a length of messenger equal to, or greater than, the depth of water at the proposed location for the anchor. Bury the messenger wire combination from the log anchor to the water's edge (low-tide mark).

(4) Enter the water, with the laying vehicle (if a Dukw is used) pulling the messenger-wire combination with it. Men on shore feed the messenger-wire combination to the laying vehicle. When the messenger becomes taut, throw rock anchor overboard and proceed as described below.

j. Laying procedure. In good weather, wire can be laid at the rate of 3 to 6 miles per hour.

(1) For laying wire using Reel Unit RL–31, a suitable team consists of a team leader, a pilot, and two additional men. The vehicle must be anchored in position when splices are made. It is very important to allow enough time for this operation.

(2) For laying wire using the figure-eight method, a suitable team consists of a team leader, a pilot, one man to guide the wire over the stern, and two men to assist easy unfolding of wire from the figure-eight.

(3) For laying wire using the large jack-mounted reel, a suitable team consists of a team leader, a pilot, one man to pay off the wire, and two men to turn the jack-mounted reel. If the entire run cannot be made from one reel, hold the end of the laid wire in place

with a small anchored boat or buoy (empty oil dr
while the laying vehicle returns to shore for anc
full reel.

(4) Since the wire must be at the bottom of t
water, the length of wire required will be greater tha
the actual distance covered, especially if any grea
depth is encountered. Wire must be paid out gen
erously, with plenty of slack to provide the neces
sary extra length. In all operations choose the rou
that will avoid regions of rapid tidal currents, be
cause such currents will cause undesirable motion o
the wire. If currents greater than 2 or 3 miles pe
hour are encountered, reinforce the wire with th
messenger in that region.

k. Shore approach at end of run. Two procedure
are possible in making the shore approach at the en
of the run—

(1) In most cases the wire can be laid on the sho
and the messenger reinforcement tied to it after
wards. Anchor the messenger to the same type o
log anchor used at the starting point, tie it to th
wire up to the water line, and bury it with the wir
to the low-tide water line. Then under-run the wir
with a boat or amphibious vehicle and tie the mes
senger to it as the under-running proceeds. Attac
the rock anchor to the messenger at a distance fro
the last tie equal to the depth of water over th
anchor. When the messenger is taut, drop the anchor
and discontinue the under-running.

(2) If an exceptionally long messenger reinforce
ment is required at the final shore approach, tres
it as a new starting point, using the procedure out
lined in **h** above. The end of the laid wire must b

held in position offshore by an anchored boat or buoy while the approach is made. Join the two-wire sections afterwards by an offshore splice made in the laying vehicle.

36. JUNGLE AERIAL WIRE LINE CONSTRUCTION. Circumstances may arise in jungles which require communication lines of longer life and greater transmission range than can be obtained from a single, twisted-pair circuit laid on the ground. Jungle aerial wire lines are recommended if it is impractical to construct tactical open wire for any of the following reasons: suitable materials not available, insufficient time to clear a suitable right-of-way, a clearly visible right-of-way undesirable for tactical reasons, construction is temporary, or traffic load does not warrant the effort required for constructing tactical open-wire routes. Spaced twin-pair circuits of field wire (one twisted pair for each side of the circuit), supported on insulators suspended from trees or cut native saplings, will provide longer line communication construction which will be satisfactory.

a. General material requirements. Materials used for jungle wire line construction must be light in weight because of the difficulty in transporting heavy loads through jungle terrain. The materials required for constructing this type of line are easily transportable by manpack. The techniques require a minimum of tools and materials and make use of natural supports as much as possible.

b. Planning. Moisture and fungus growth cause rapid deterioration of insulation. Falling branches and palm fronds cause excessive wire breakage. Con-

stant maintenance is required to keep the line in operation. However, if the line is carefully planned and constructed, maintenance will be greatly reduced resulting in better transmission and the saving of valuable time, labor, and materials. Select the shortest and best possible route which will allow the line to be constructed in the shortest time with a minimum of materials. Consider the available materials, equipment, traffic requirements, and construction personnel when planning the line construction.

c. Materials and equipment. (1) *Types of wire.* Field and assault type wires are suitable for jungle aerial wire line construction. The weights per mile of twisted-pair wire, the transmission characteristics of spaced twin-pair circuits and circuit lengths for different transmission requirements are shown in table I.

Table I

Type of wire	Approximate weight per mile (lb)*	Approximate attenuation (db per mi)**	Approximate circuit length (mi)	
			6 db	12 db
Wire W–110–B	130	0. 6	10	20
Wire W–130–( )	34	1. 1	5. 5	10. 9
Wire WD–1( )/TT	48	0. 65	9. 2	18. 5

*Weights are for wire only and do not include weight of container.
**Wet-weather attenuation of spaced twin-pair circuits of 1,000 cycles per second.

(2) *Wire dispenser.* Expendable wire dispensers eliminate heavier reels and reel units (par. 23j). Wire is payed out by anchoring the payout end of the wire and carrying the dispenser along the route.

The wire dispenser may be mounted on a quartermaster packboard (fig. 88) or carried by the use of a shoulder or hand sling.

Figure 88. Paying out assault wire from wire dispenser mounted on quartermaster packboard.

(3) *Insulator IL–3/G.* Insulator IL–3/G is an oval-shaped, split-type insulator. It may be made of porcelain, plastic, or glass and weighs approximately 4 to 6 ounces (fig. 89).

(4) *Tools.* Tools needed for constructing jungle aerial-wire lines include axes; machetes; lineman's equipment, which includes tree climbers, body belts and safety straps, pliers, knives, and tape. Packboards or carrying straps may be required for carrying bulk materials.

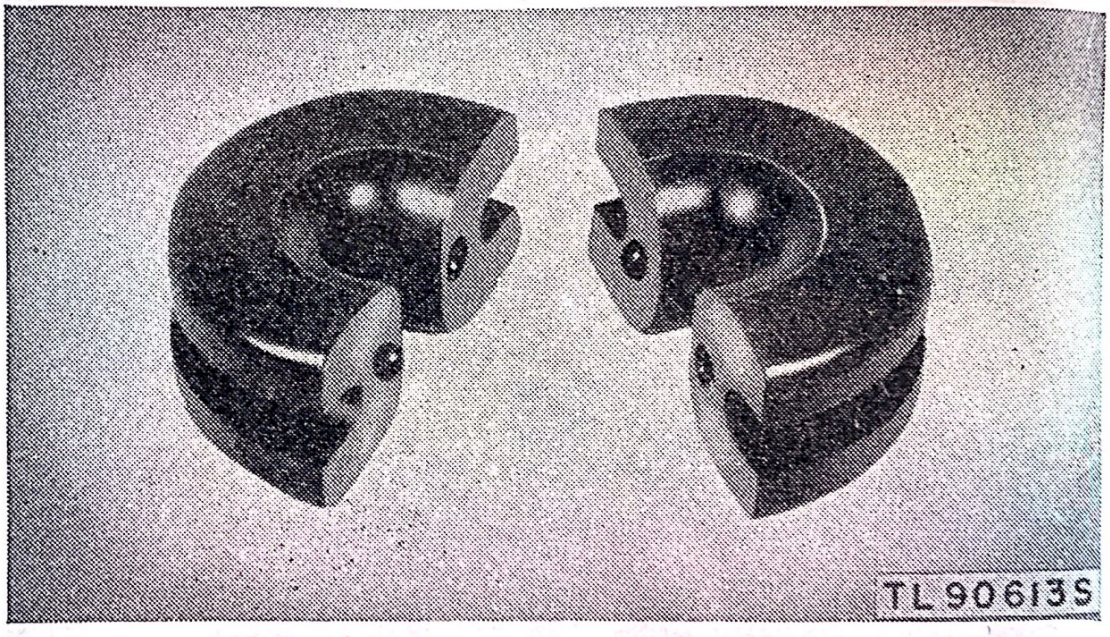


Figure 89. Insulator IL–3/G.

(5) *Construction.* A single-spaced, twin-pair circuit usually will be sufficient to fulfill normal requirements for a line of this type. If traffic conditions warrant, an additional, spaced, twin-pair circuit can be installed approximately 12 inches below the first circuit. Tie both lines to the same tree supports (using separate insulators) and transpose at alternate points (fig. 90).

(6) *Use of carrier and teletypewriter.* Carrier equipment may be used if traffic loads require addi-

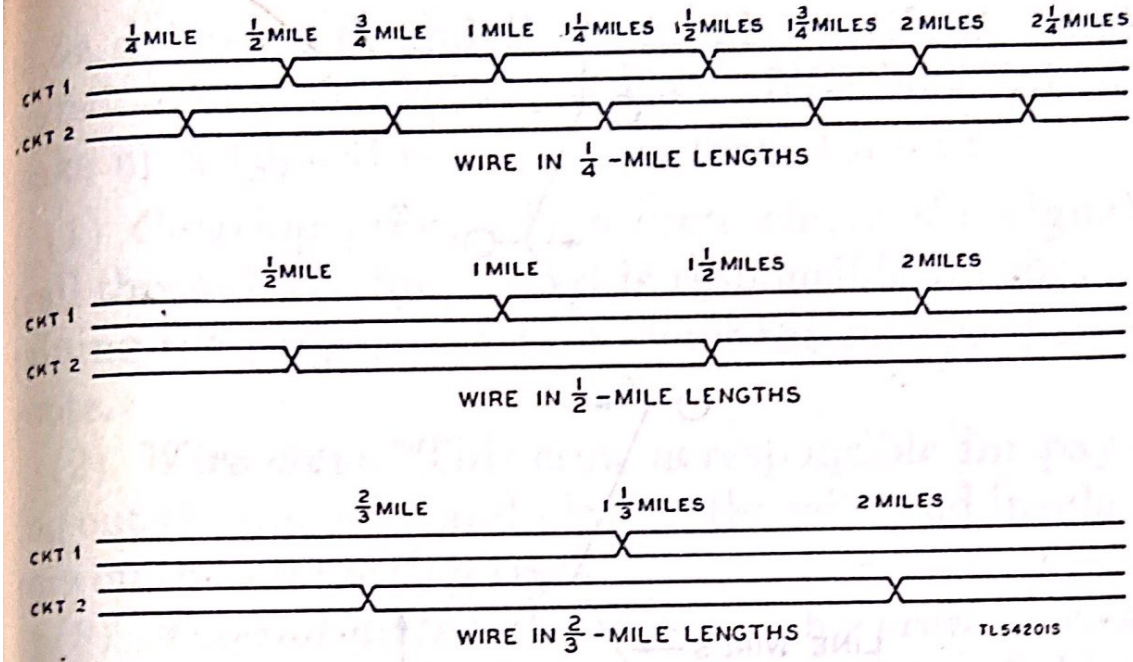


Figure 90. Transposition scheme for two spaced twin-pair circuits on the same supports.

tional circuits and if equipment is available. However, because of unbalances existing in this type of construction, only one carrier system can be used on the same route. Ground-return simplex teletype can be used satisfactorily on full length circuits installed for voice operation.

d. Lay-out of line route. Select the line route from available maps or aerial photographs. For best results, reconnoiter the area before construction begins. Consider avoidance of swamps, streams, steep hills, and ravines. Mark the boundaries of the signal trail and select trees to be used as supports. Supporting trees should be located on either side of the signal trail with normal span lengths not exceeding 100 feet. Select trees not less than 4 inches in diameter when practicable. Remember that the line wires *must pull away* from the supports (fig. 91) since insulators are suspended from the tree with a short piece of field wire. Where no trees are available, mark the loca-

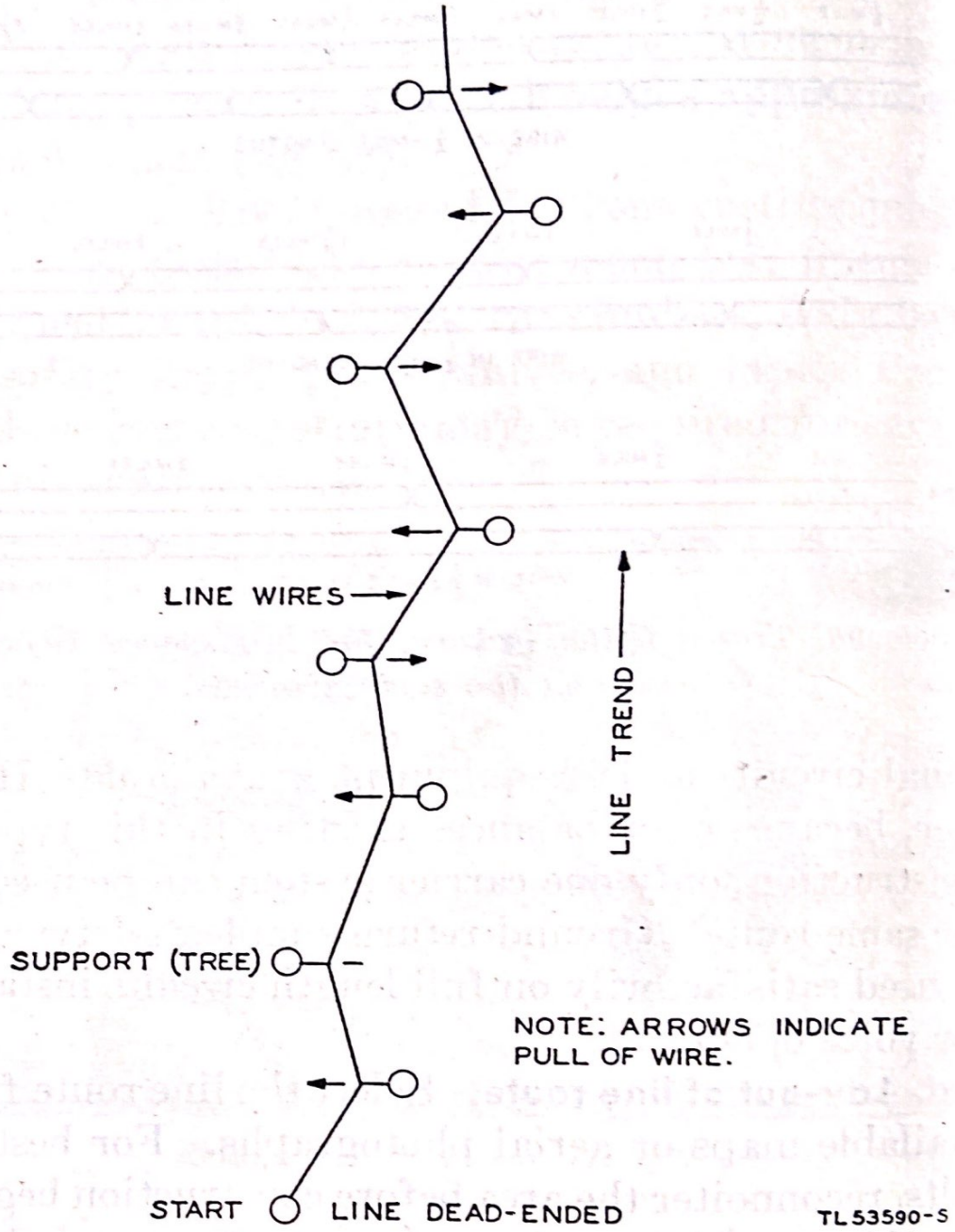


Figure 91. Sketch of typical jungle aerial wire line.

tion for placing poles cut from native saplings. T check construction and for later use in line main tenance, make a sketch for the record, showing th location of supporting trees, transposition points, an direction of line trend.

e. Construction-team organization. The numbe of personnel required depends upon the materials t be used, the terrain to be crossed, the length of lin

to be constructed, and the tactical situation. Suggested crews, according to their functions, which make up a typical construction team follow:

(1) *Clearing crew.* This crew clears the signal trail through the jungle and is responsible for maintaining the proper direction along the proposed line route.

(2) *Wire crew.* This crew is responsible for paying out the line wire and placing the wire and insulators on the supporting trees.

(3) *Material-distribution crew.* This crew carries or transports and distributes all materials needed by the clearing and wire crews.

(4) *Security.* Sufficient personnel must be provided to furnish protection for the construction team where there is danger of enemy attack.

f. Clearing signal trail. Clear a signal trail approximately 8 feet wide along the selected wire route. Cut and remove the heavy undergrowth and overhead foliage which may interfere with the wire stringing. Make no attempt to clear out all the overhanging foliage. If the trees to be used for supports have not been designated, select and mark them (as described in **d** above) ahead of the clearing crew.

g. Placing wire. (1) *General.* Place insulators and scrap wire for ties at each previously selected support. The wire is dead-ended at the start of the line and then payed out along the route.

(2) *Attachments.* Place the line wire inside the insulator and tie the two halves of the insulator together with the hanger wire. Use one wrap and two half hitches on the outside insulator and the weave tie on the insulator nearest the support (fig. 92).

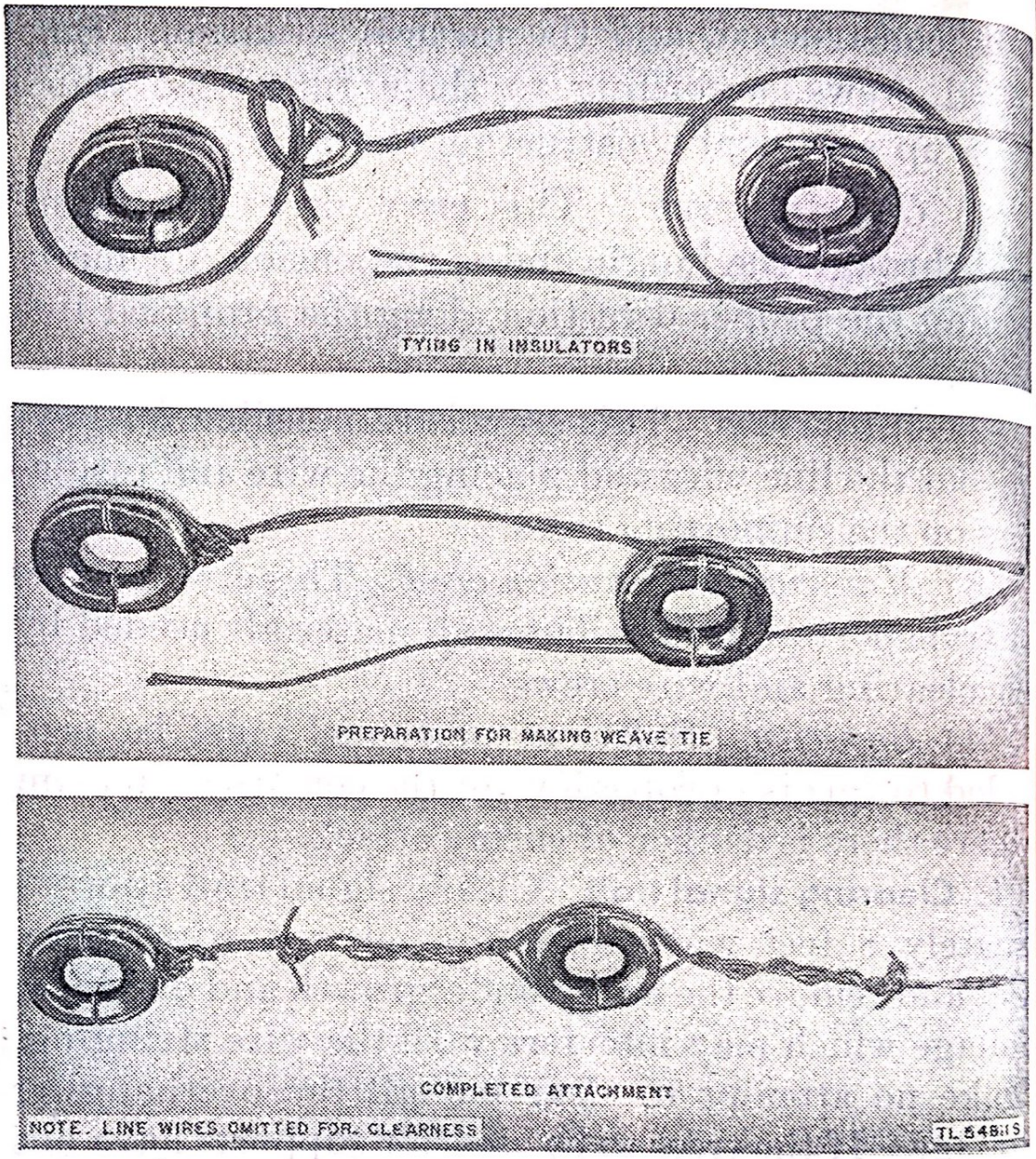


Figure 92. Intermediate attachment ties.

When making up attachments for intermediate supports, space insulators 12 inches apart and 18 inches from the support as shown in figure 93. Where the circuit is dead-ended, each insulator is tied to an individual hanger and two hangers spaced 12 inches apart on the supporting tree. For attachments to the supports, take 1 turn around the tree (2 turns when using Wire W–130–( )) and secure with two half hitches. For attaching to insulator, take 1 turn

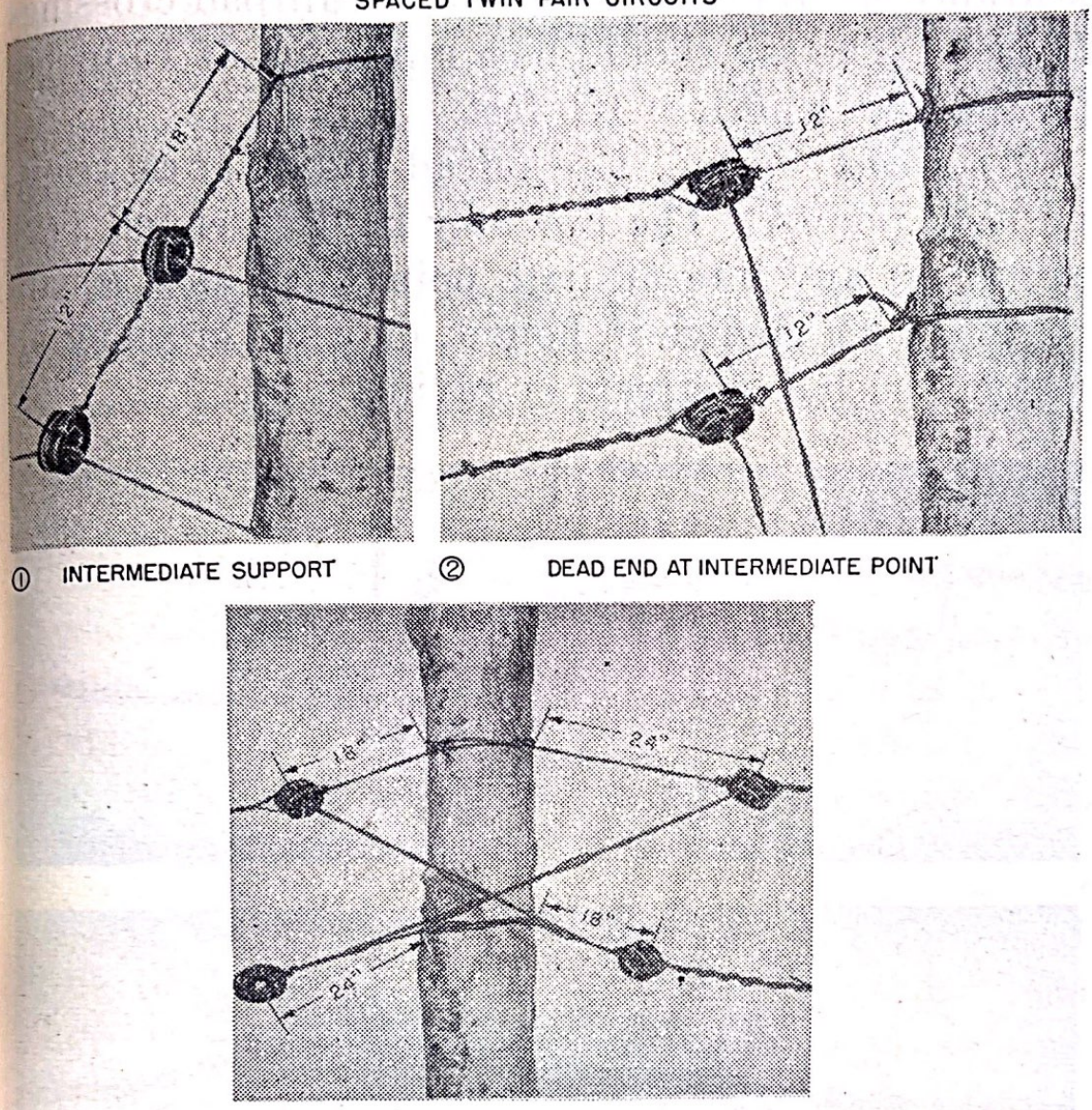


Figure 93. Spaced twin-pair circuit.

around the insulator and secure with two half hitches. Tie the line wire to the dead-end by using a single strand of field wire wound twice through the insulator and weave along line wire to form a weave tie (fig. 94).

(3) *Clearance and sag.* Make attachments to supports as high as practicable. Where vehicular traffic is anticipated, maintain clearance for cross-country lines at a minimum of 14 feet. At highway crossings,

clearance should be 18 feet, and at railroad crossings 27 feet. The sag should be a minimum of 13 inches for the span length of 100 feet.

(4) *Dead-ending.* Use a dead-end tie at all transposition points. The line may be dead-ended ((2) above) at any intermediate point such as a square corner, for a change in height, or when crossing an obstacle such as a stream or ravine.

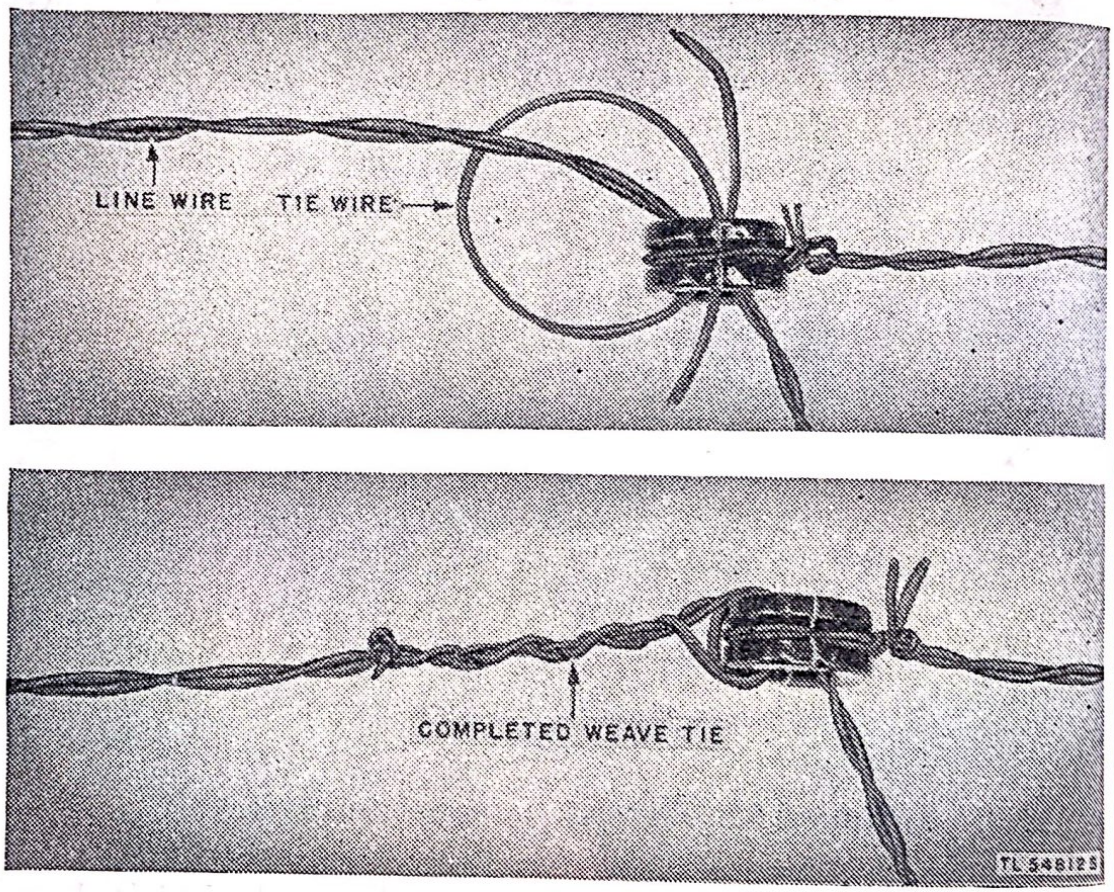


Figure 94. Steps in tying in line wire at dead-end.

(5) *Transpositions* (*fig. 90*). Accurate measurements between transposition points are simplified by installing transpositions at the end of wire coils. Dead-end the line wires in both directions and make transpositions by splicing the individual conductors of line wires through and between the two dead-ends at the support. Make all transpositions *left*

over *right*, looking in the direction of line trend. Splices will be standard field wire splices. When splicing the two conductors of each twisted pair, stagger the splices and insulate each conductor separately.

h. Precautions. Do not use the ordinary lineman's climbers for climbing trees. Use the longer gaff on tree climbers for greater safety. When not actually working on a support, remove tree climbers to prevent injury to using personnel or damage to the climber gaffs. High humidity and fungus growth cause deterioration of leather equipment in the jungle. Take good care of body belts and safety straps to prevent accidents. For information on the care and preservation of leather climbing equipment, refer to paragraph 21**c**.

37. USE OF CABLES AT TERMINALS. At command posts of higher headquarters, and in other areas where there is a tendency for wire communication lines to become congested, 5- and 10-pair cables may be used to reduce the time of installation and to consolidate overhead circuits in one or more cables. For additional data and details of construction, testing, and splicing, see TM 11–371.

38. LOADING OF FIELD WIRE LINES. a. Purpose. Telephone transmission over long field wire circuits can be improved by the use of loading coils to add inductance to the line and thereby counteract the capacitance of the wire. Such coils increase the maximum length of line over which satisfactory transmission can be obtained by 50 to 300 percent, depending upon the type of loading and spacing

used. Lines less than 10 miles in length are usually satisfactory without the use of the coils.

b. Description. Loading Coil C–426 consists of a 44-millihenry coil housed in an oval-shaped, die-cast aluminum case with a removable cover to permit access to the wire binding posts for testing purposes. A synthetic rubber gasket for the cover and synthetic rubber bushings in the wire entrances are provided as moisture seals. The coil weighs about 22 ounces (fig. 95).

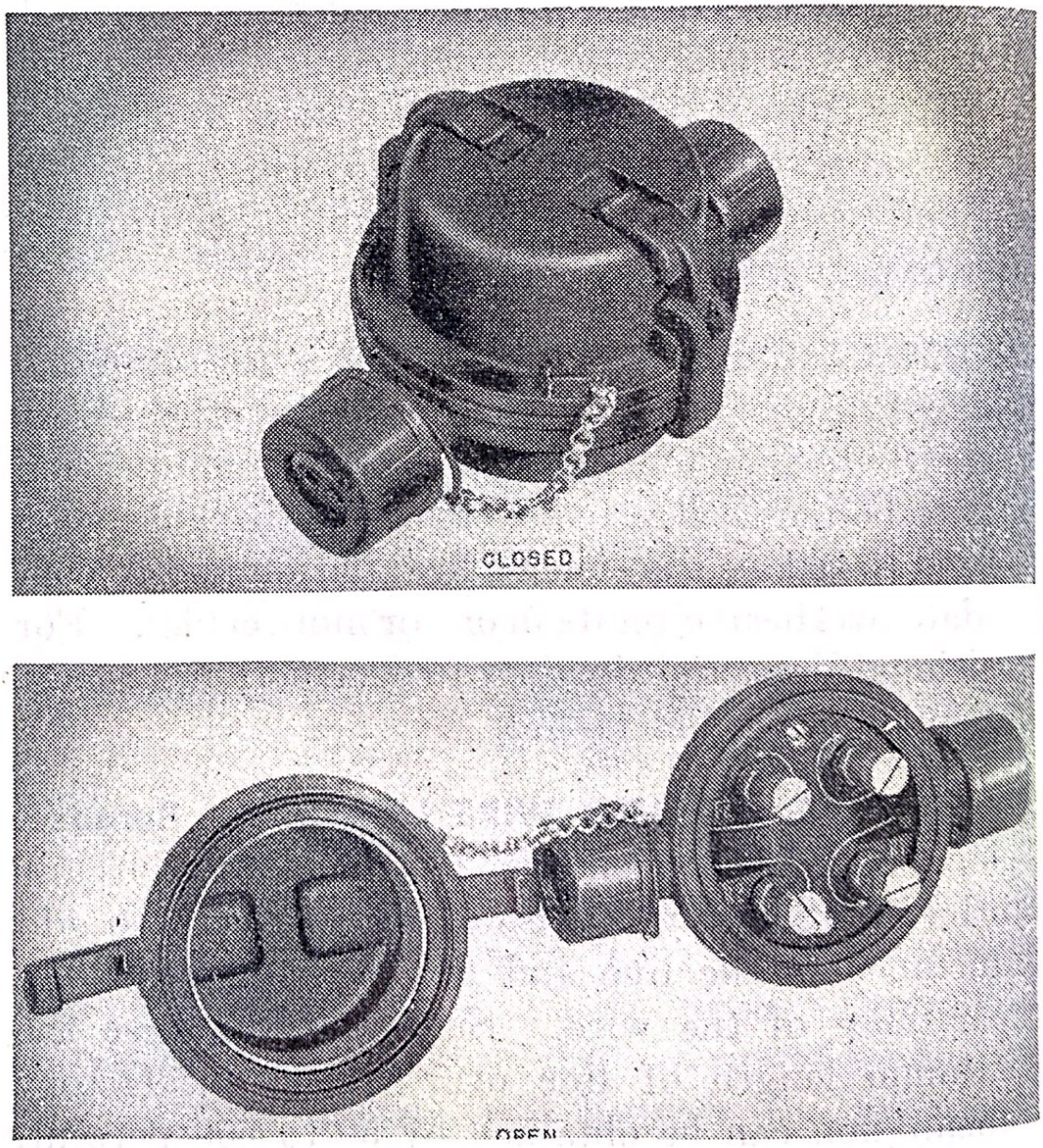


Figure 95. Loading Coil C–426.

c. Technical characteristics.

Wire	Spacing (mi)	Talking range in miles	
		w/coil	w/o coil
W–110–B	1	19. 3	11. 7
W–143	5/8	81. 6	23. 8
WD–1( )/TT	1	34. 0	20. 0
WD–14( )/TT	1	32. 8	15. 0

Note.—This type of loading provides a frequency channel sufficiently wide for operation of Telegraph Terminal Set AN/TCC–1 (speech plus duplex) and Telegraph Carrier Terminals CF–2 and CF–6–( ).

d. Spacing of coils in line. Loading Coil C–426 may be installed at intervals of 1 mile in Wires W–110–B, WD–1( )/TT, WD–14( )/TT, and every five-eighths mile in Wire W–143. The distance between one terminal of a circuit and the first coil, or the distance between the other terminal and the last coil, is known as an *end section.* The length of this section must be at least 0.2 mile and not more than 1 mile. The spacing of the coils between the end sections should not deviate more than 5 percent from the 1-mile or 5/8-mile spacing.

e. Installation. (1) *Wire WD–1( )/TT or W–110–B.* (*a*) Open the case cover.

(*b*) Loosen caps at wire entrances until no pressure is being applied to the synthetic rubber entrance bushings.

(*c*) Loosen the binding-post nuts.

(*d*) Cut conductors of wire evenly.

(*e*) Insert conductors of one pair through the entrance bushing adjacent to binding posts T1 and R1. Pull approximately 3 inches of wire beyond the inside of the housing.

Note. If aged Wire W-110 with loose cover is encountered remove outer cover for approximately 6 inches and proceed as directed in (*e*) above. If cover is removed, cover with friction tape any insulation exposed after caps are tightened.

(*f*) Crush and remove the cover and insulation from each conductor back from a point 1½ inches from the ends.

(*g*) Prepare the bared ends of both conductors by separating the steel and copper strands and seizing the steel strands with the copper strands for approximately one-half inch. Cut off the remaining wire ends.

(*h*) Arrange the wire by the T1 binding post to form a half loop around the binding post and insert the bared conductor in the slot so that approximately one-eighth inch of the conductor extends beyond the slot. Tighten the binding-post nut.

(*i*) Repeat the above step for the wire at binding post R1.

(*j*) Remove the slack in the wires around the binding posts by pulling the wires out through the bushing so that the half loop is snug around the binding post.

(*k*) Tighten the cap at the wire entrance as tightly as can be done by hand.

(*l*) Repeat (*d*) through (*k*) above for the other pair of wires to be attached to binding posts T2 and R2.

(*m*) Replace cover and lock it in place. When replacing cover, be certain that the cover chain or other foreign objects are not caught between the cover and the case.

(2) *Wire W–143.* (*a*) Open the case cover and loosen the caps at the wire entrance until no pres-

sure is applied to the rubber bushing. Loosen the binding-post nuts.

(*b*) Using a knife, cut a 7-inch slit, starting from the end of the *outer cover* on the *flat side* of each piece of wire to be connected to the loading coil (fig. 13).

(*c*) Remove the outer cover and the carbon-impregnated paper shield from the wires for the distance of the slit. Cut off the outer cover and shield squarely, leaving the insulation exposed.

(*d*) Nick the insulating web of each wire with a knife. Working from the end of each wire, carefully slit the conductors by hand for 6 inches, leaving the conductors in the remaining inch joined together by the insulating web.

(*e*) Using rubber Tape TL–192 (or Tape TL–94), tape up the crotch of both wires as shown in figure 97.

(*f*) Insert conductors of the pair to be connected to binding posts T1 and R1 through the adjacent entrance bushing, and pull the wire through until the rubber tape around the wire at the crotch rests firmly against the entrance bushing. Overcome friction by slightly wetting the ends of the wire. Taking care to prevent the forming of kinks, insert in the entrance bushing both conductors of the pair of wires and pull them through at the same time.

(*g*) With the rubber tape resting firmly against the entrance bushing, hand-tighten the wire-entrance cap.

(*h*) Arrange the wire by the T1 binding post to form a half loop around the binding post and determine the point where the conductor will enter the slot. Remove the insulation from this point to the end of the conductor.

(*i*) Insert the bared conductor in the slot and tighten the binding-post nut by hand.

(*j*) Cut off excess bared conductor.

(*k*) Repeat (*h*) through (*j*) above for the wire at binding post R1.

(*l*) Repeat (*f*) through (*k*) above for the pair to be connected to binding posts T2 and R2.

(*m*) Be certain that the cover chain or other foreign objects are not caught between the cover and the case. Replace cover and lock it in place.

(*n*) Cover exposed rubber tape on both wires at entrances with friction tape. Bring tape up flush with entrance bushing.

Note. On Wire W–143, constructed without the insulating web between the conductors, performance of instructions in (*d*) and (*e*) above will not be necessary. Pull the wire through until the outer cover is flush with the entrance bushing ((*f*) above). Cover any exposed insulation with friction tape.

(3) *Loading Coil C–426 used as connector only (Wire W–143).* (*a*) Follow instructions outlined above in (1) (*a*) to (*c*), inclusive.

(*b*) Using a knife point, make a 7-inch slit from the end of the *outer cover* on the *flat side* of the wire to be connected to the T1 and R1 binding posts of the loading coil. Remove the outer cover and the carbon-impregnated paper shield of the wire for the distance of the slits as described in 2 (*b*) above.

(*c*) Follow instructions as outlined above in (1) (*f*) to (*m*), inclusive.

(*d*) Repeat operations in (1) (*h*) and (*i*) above for the wire to be connected to binding posts T2 and R2.

(*e*) Arrange the wire by binding post T2 to form a half loop snugly around the binding post and determine the point where the conductor will enter the slot. Remove the insulation from this point to the end of the conductor. Insert the bared conductor into the slot and tighten the binding-post nut by hand.

(*f*) Carry the remainder of the bared wire to binding post T1 and insert in the same slot with the wire previously connected to that binding post. Be sure to retighten the binding-post nut.

(*g*) Repeat the operations in (*e*) and (*f*) above for the wire on binding post R2.

(*h*) Replace the cover and snap lock in place. Cover exposed rubber tape (on both wires) at entrances with friction tape. Bring tape up flush with entrance bushings.

f. Loading Coil C–114. This coil has an inductance of 88 millihenries. Equipped with a rubber gasket, hinged cover, and a latch, the entire unit weighs 24 ounces. Four binding posts terminate the two coils contained within the metal case. Loading Coil C–114 is not waterproof.

g. Technical characteristics

Wire	Spacing (mi)	Talking range in miles	
		w/coil	w/o coil
W–110–B	1	22. 0	11. 7
W–143	⅝	79. 0	23. 8
WD–1( )/TT	1	44. 5	20. 0
WD–14 ( )/TT	1	44. 2	15. 0

Note. This type of loading provides a frequency chan sufficiently wide for operation of Telegraph Terminal S AN/TCC–1 (speech plus duplex) and Telegraph Carri Terminal CF–2 and CF–6–( ).

h. Spacing of coil in line. See **d** above.

i. Installation. (1) *Wire W–110–B.* Install th coil in a field-wire circuit by connecting the field wir from one direction to the two adjacent binding post marked L1 and L2 (fig. 96). Connect the field wir

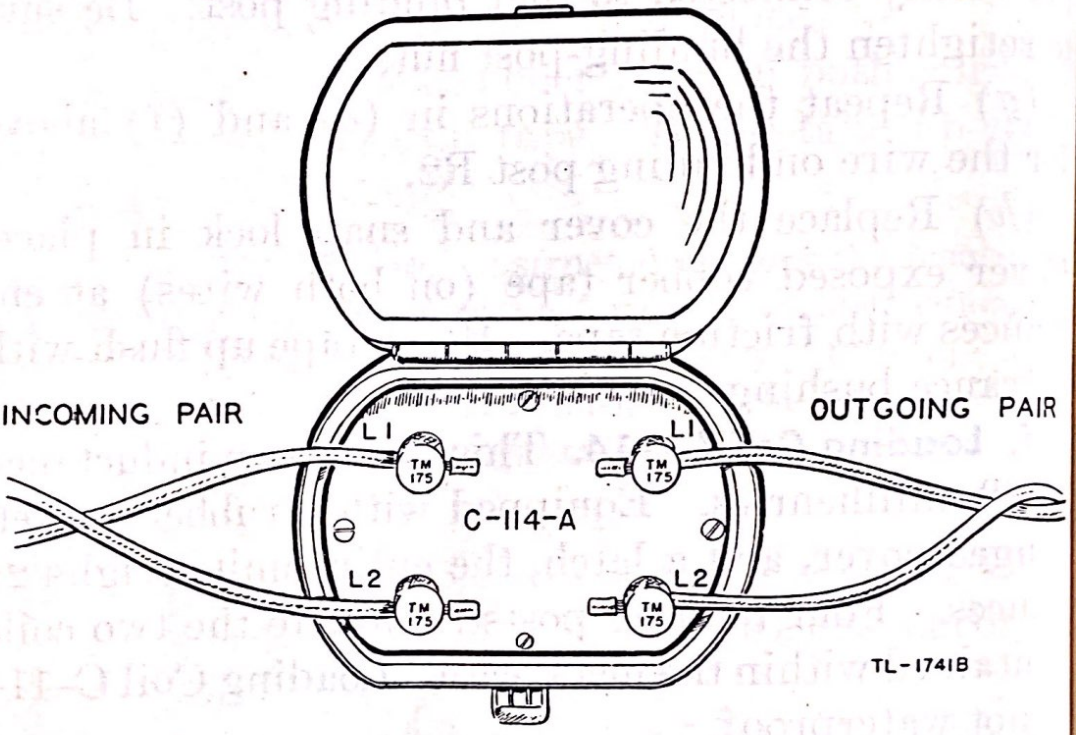


Figure 96. Method of connecting Coil C–114 in field wire line.

from the other direction to the two remaining binding posts marked in a similar manner. Skin the wires when making these connections to the terminals. All four wires must fit snugly into the grooves in the rubber gasket when the cover is closed. Free the coil connections of strain by tying the line wires to a near-by post or tree. This avoids damage to the coil or prevents the connections from being pulled out.

(2) *Wire W–143.* Connect Wire W–143 to Loading Coil C–114 as follows:

(*a*) Remove about 4 inches of the outer cover. Do not split the two conductors at this time.

(*b*) With a piece of rubber tape, make a complete wrap around the rubber-insulated wires flush with the fiber outer cover (fig. 97①).

(*c*) Extend the rubber tape for about 1 inch and then split the two wires, bending each one at a right angle. Continue to wrap the rubber tape on one of the wires (fig. 97②).

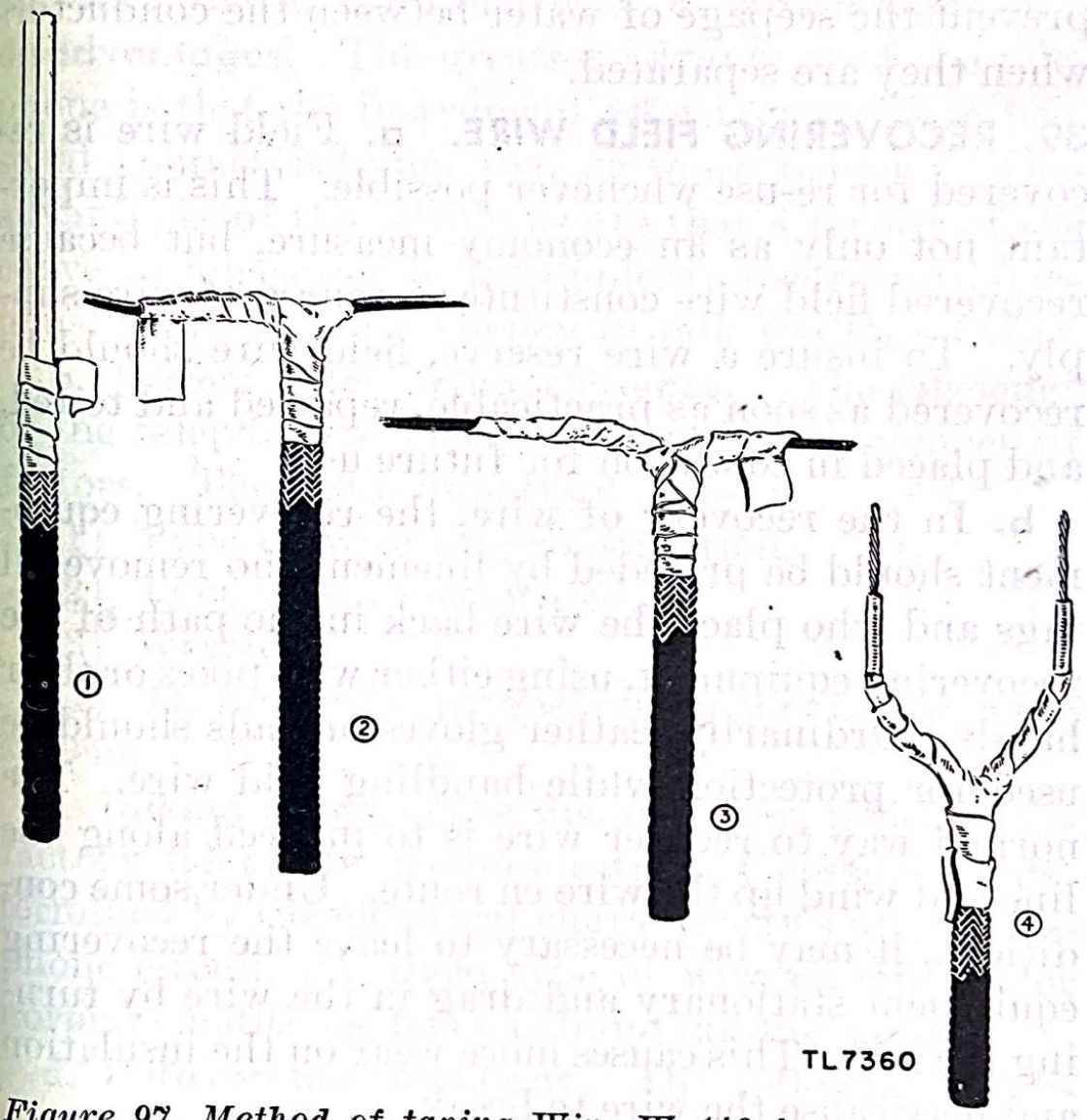


Figure 97. Method of taping Wire W–143 for connection to Coil C–114.

(*d*) Reverse and tape back over the crotch and c on the other wire as shown in figure 97③. Reve again and terminate the wrapping at the origi starting point.

(*e*) Cover the rubber tape with a layer of fricti tape in the same manner, but make the starting poi on the fiber insulation of the wire.

(*f*) Skin the ends of the wires and form them f connection to the coil terminals in the same mann as for field wire. For the rubber tape serving, s figure 97 ④. This method of taping is necessary prevent the seepage of water between the conducto when they are separated.

39. RECOVERING FIELD WIRE. **a.** Field wire is r covered for re-use whenever possible. This is impo tant not only as an economy measure, but becaus recovered field wire constitutes a source of wire sup ply. To insure a wire reserve, field wire should b recovered as soon as practicable, repaired and teste and placed in condition for future use.

b. In the recovery of wire, the recovering equip ment should be preceded by linemen who remove a tags and who place the wire back in the path of th recovering equipment, using either wire pikes or thei hands. Ordinarily leather gloves or pads should b used for protection while handling field wire. Th normal way to recover wire is to proceed along th line and wind up the wire en route. Under some con ditions, it may be necessary to leave the recoverin equipment stationary and drag in the wire by turn ing the reel. This causes more wear on the insulatio and may cause the wire to break.

c. Wire is never recovered without authority o the next higher headquarters.

CHAPTER 3

FIELD TELEPHONES AND TELEPHONE CENTRALS

Section I. INSTALLATION

40. TELEPHONE CAPABILITIES. a. Advantages and disadvantages. The greatest advantage of the telephone is that the instrument affords immediate personal contact between two or more persons. Disadvantages of the telephone are that a record of the conversation cannot be kept unless a recording device is used and that a tendency to talk too long exists.

b. Factors determining efficiency. The efficiency of the telephone system depends upon a number of factors. The most important are—

(1) Type of wire line construction.

(2) Type of equipment used.

(3) Weather.

(4) Training of personnel operating and using the system.

c. Talking range. The distance over which satisfactory telephone communication is possible is determined by the electrical characteristics of the telephone circuit. A given type of wire circuit, under normal conditions, has a definite talking range.

d. Unfavorable conditions. The following conditions tend to decrease the efficiency of telephone circuits and the range of telephone communication—

(1) Snow, ice, rain, heavy dew, or fog.

(2) Poor electrical insulation between wires and ground.

(3) Moisture in the telephone instrument, especially in the transmitter.

(4) Weak dry batteries in local battery (magneto) telephones.

(5) Additional telephones bridged across a circuit.

(6) Additional switchboards in a connection.

41. TELEPHONE CENTRALS AT COMMAND POSTS. A telephone central is established at each echelon of a headquarters where two or more local telephones are installed. Such a central makes possible a flexible intercommunication between local telephones and provides connections to trunk circuits leading to other units.

42. OTHER TELEPHONE CENTRALS. Telephone centrals are also installed at points other than an echelon of a headquarters, principally for the purpose of trunk switching. Judicious use of such telephone centrals makes it possible to furnish better telephone service with the same number of trunks. On the other hand, the telephone centrals require more personnel and equipment; necessitate an additional switching operation, thus increasing the possibility of interruptions to service; and introduce additional transmission losses.

43. TYPES OF FIELD TELEPHONES. a. Telephones EE–8–A and EE–8–B. These field telephones can be used on either local battery or common battery systems and have other applications which are described

in TM 11–333. The two Batteries BA–30 required for each instrument are not supplied as part of the telephone but must be requisitioned separately. An external 3-volt battery may be used instead of the two Batteries BA–30, provided it is connected to the external battery binding posts and the internal batteries are removed. A view of Telephone EE–8–B with the case opened is shown in figure 98. The handset and cord fit into the case when the instrument is not in service. The only difference between Telephone EE–8–A and Telephone EE–8–B is that a short steel chassis and Generator GN–38–A or GN–38–B are used in Telephone EE–8–B instead of an aluminum alloy chassis and Generator GN–38 which are used in Telephone EE–8–A.

b. Telephone EE–8. This instrument operates on local or common battery circuits and is similar to Telephone EE–8–A. For a detailed description, see TM 11–333.

c. Telephone TP–9. This is a portable field telephone designed to provide two-way communication on lines too long to allow satisfactory operation when using the EE–8–A or EE–8–B. When a TP–9 is substituted for an EE–8–B on each end of a line, the transmission range will be increased 2½ to 3 times. When only one Telephone EE8–B is replaced by a TP–9, the increase in range will not be so great and the operator at the TP–9 will receive a louder signal than the operator of the EE–8–B. The TP–9 consists of handset, generator, and ringer (components of the EE–8–B) plus a one-tube transmitting amplifier and a two-tube receiving amplifier mounted in a case that measures 8½ inches by 9¼ inches by

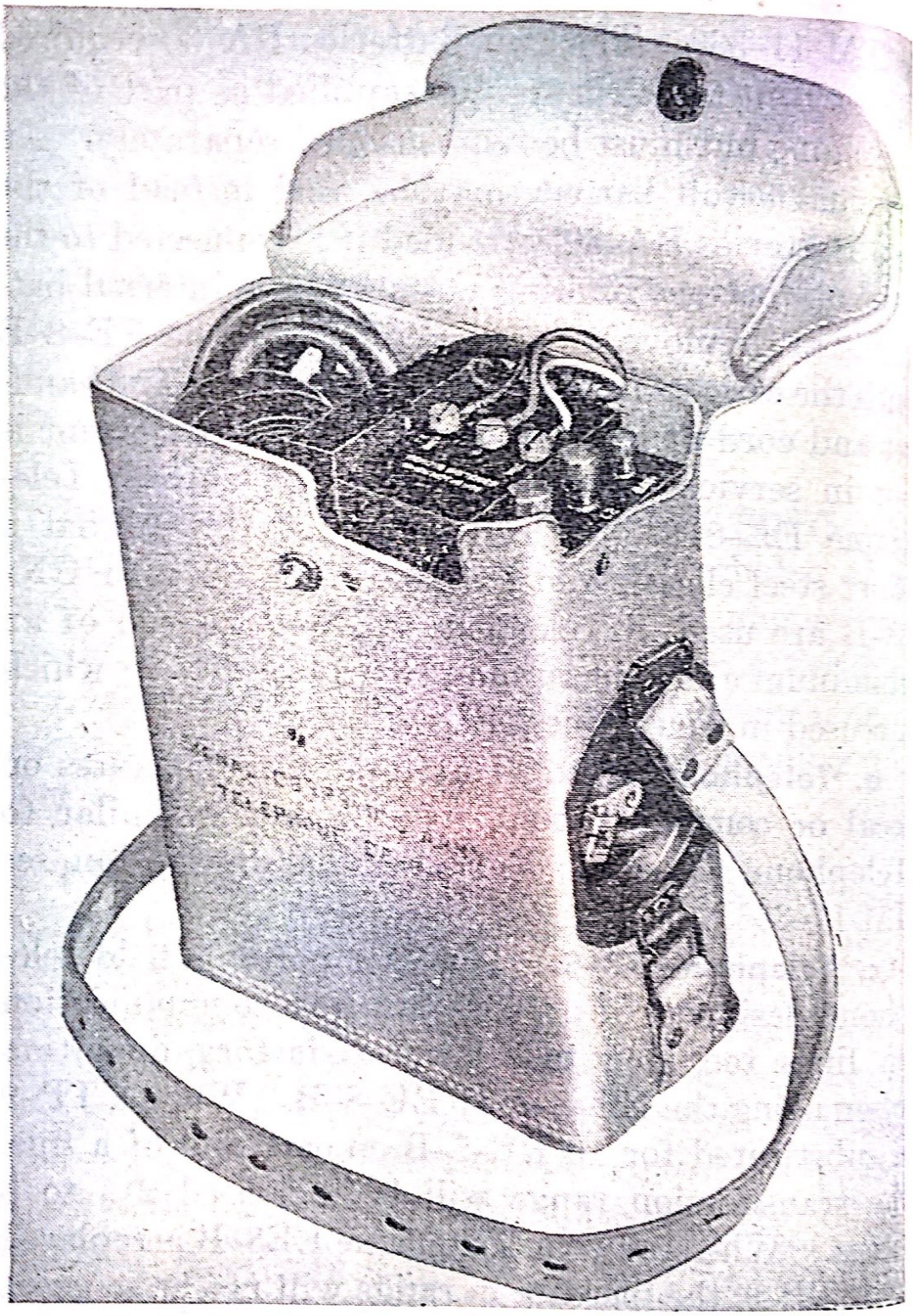


Figure 98. Telephone EE–8–B, case opened.

12½ inches. The telephone requires one Battery BA–27, one Battery BA–65, and three Batteries BA–2; these batteries are not provided with the telephone. A switch is provided to convert the telephone

to the equivalent of a Telephone EE–8–B. A two-position switch is provided to shift from the ringer to a drop for silent signaling. On long lines the drop must be used in place of the ringer. The TP–9 is connected to the line wire in the same manner as the EE–8–B.

d. Telephone TP–3. (1) This telephone provides two-way signaling and voice communication without the use of batteries. Instruments of this type are designated as sound-powered telephones. The TP–3 may be connected by metallic or grounded circuits, composed of field wire, open wire lines, and cable, to any one of the following types of circuits and equipment:

(*a*) Sound-powered telephones.

(*b*) Local battery (magneto) telephones.

(*c*) Local battery (magneto) telephone switchboards.

(*d*) Two-way ring-down trunk circuits of common battery telephone switchboards.

(*e*) Common battery line circuits of common battery telephone switchboards.

(2) The TP–3 has been classified as substitute standard, pending the development of a smaller, more compact, and more moisture-resistant, sound-powered telephone. However, its major component, the sound-powered Handset TS–10, is used as part of Reel Equipment CE–11. The talking range of this handset over Wire W–110–B is 5 miles or more.

(3) Telephone TP–3 (sound-powered) may be used under gas conditions as explained in paragraph 48**b**(2) (*d*). This telephone cannot be used with Chest Set TD–3 or with Microphones T–45 and T–30.

44. TYPES OF FIELD SWITCHBOARDS. a. Switchboards BD–72 and BD–71. The BD–72 and BD–7 are portable, monocord, telephone switchboards fo use primarily on field wire systems. (See TM 11 330 for complete descriptions.) Switchboard BD–7 (fig. 99) accommodates twelve telephone lines an includes four permanently connected repeating coils Switchboard BD–71 accommodates six telephon lines and includes two permanently connected re-

Figure 99. Switchboard BD–72 set up for operation, showing terminal compartment open.

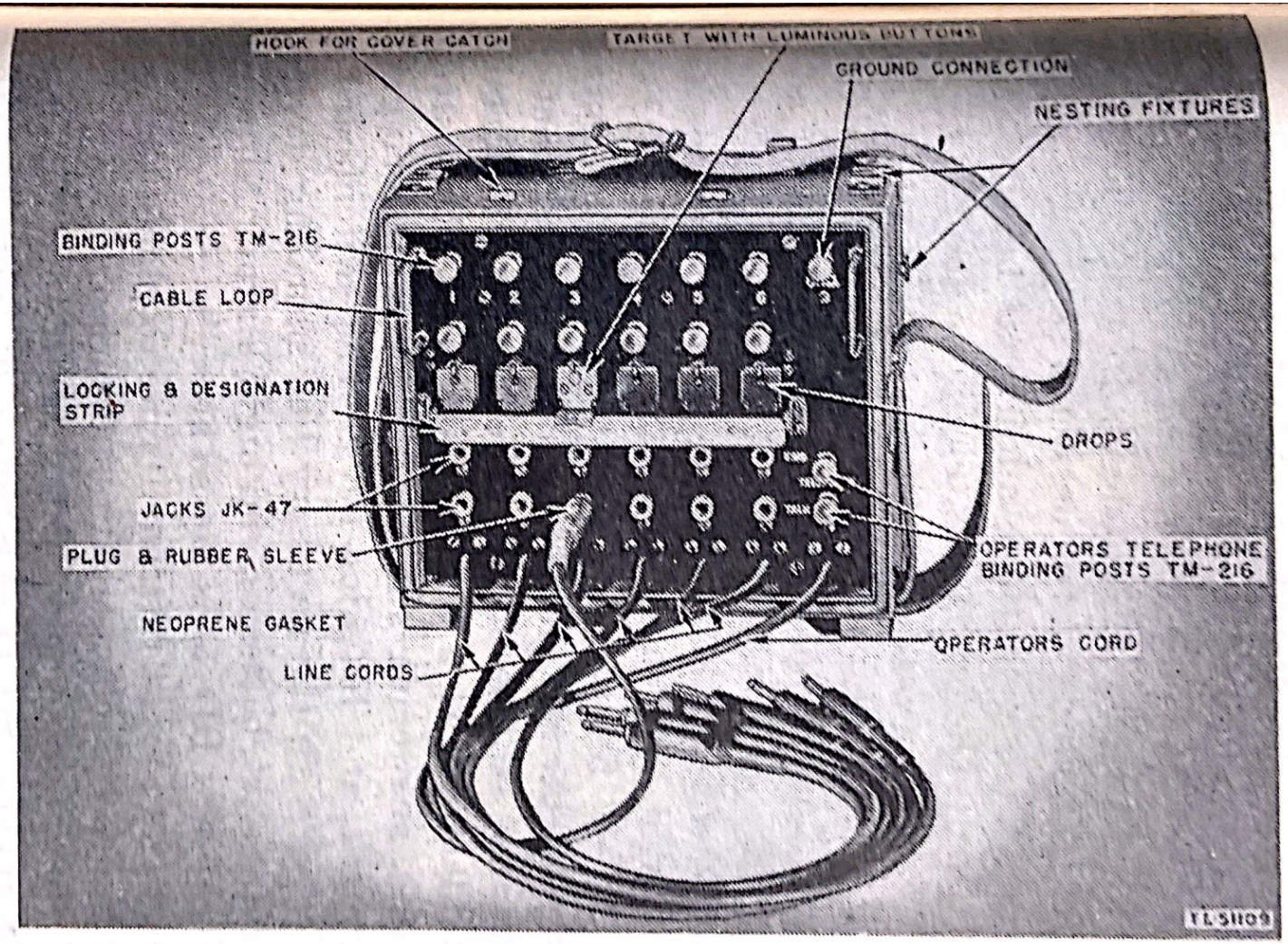


Figure 100. Switchboard SB–5/PT, front view.

peating coils. The height of the writing shelf (fro
cover of the carrying case) for each switchboa
24 inches when the legs are fully extended. Bo
types require a total of twelve Batteries BA–30, si
of which are for operation and six for spares.

b. Switchboard SB–5/PT. The SB–5/PT (fig. 100)
is a six-line, portable, monocord switchboard for us
with local battery telephone equipment. The boar
weighs 12 pounds and is designed so that it may b
nested with one to three additional boards of th
same type. The operator's telephone and the repeat-
ing coils are not made part of the switchboard. Tele-
phone EE–8, EE–8–A, or EE–8–B is required for
operation of the board. (See TM 11–2016 for addi-
tional data on the switchboard.)

c. Switchboard BD–14. This switchboard has been
superseded by Telephone Central Office Sets TC–4
and TC–12 for use as a division telephone central.
However, because of the former wide distribution,
many may still be in use. The BD–14 is a portable
switchboard with a line capacity of 40 local battery
circuits, answering and calling cords, and ringing,
ring-back, and listening keys. The switchboard is
equipped with the necessary line signaling devices,
operator's set, batteries, and night alarm. Although
Switchboard BD–14 is not so heavy as Switchboard
BD–96, its weight restricts its use to places that can
be reached by vehicular transportation.

d. Telephone Central Office Set TC–4. Telephone
Central Office Set TC–4 is used at divisions and other
headquarters requiring a switching central of the
capacity of this set. The principal equipment con-
sists of a Switchboard BD–96 and a Panel BD–97.

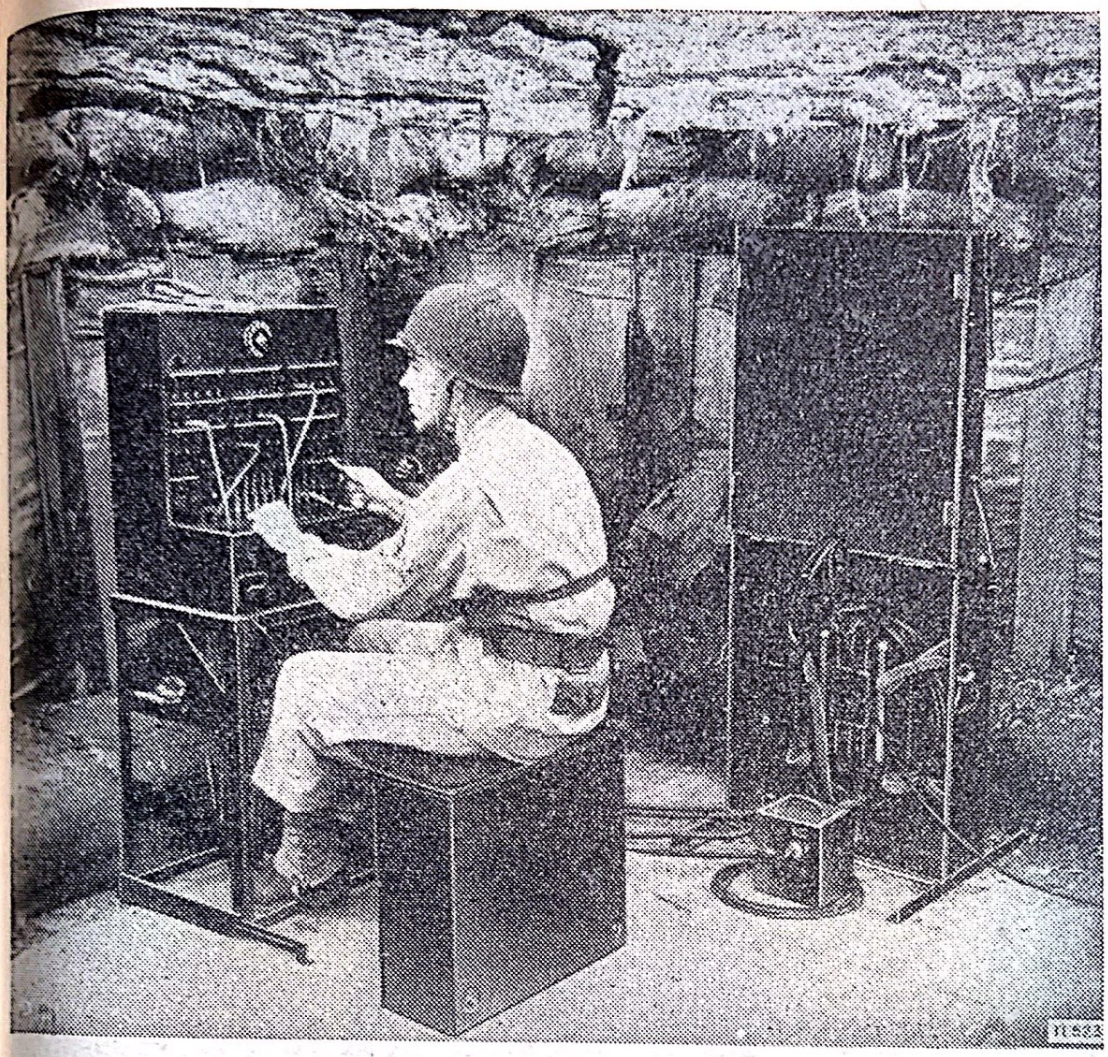


Figure 101. Switchboard BD–96 set up for operation.

For a complete description see TM 11–332.

(1) *Switchboard BD–96.* The BD–96 (fig. 101) is a complete transportable, single-position, manually operated telephone switchboard for serving magneto-line traffic as well as originating and terminating trunk-line traffic. The switchboard comprises 40 line circuits, magneto; 12 cord circuits; 4 common battery trunk circuits, manual and automatic; 1 first operator's telephone circuit with grouping key; 1 ringing circuit; 1 conference circuit; 1 dial cord circuit; 1 second operator's circuit; and 1 night-alarm circuit. In operating position, the approximate size of the switchboard is 15 inches deep by 22 inches

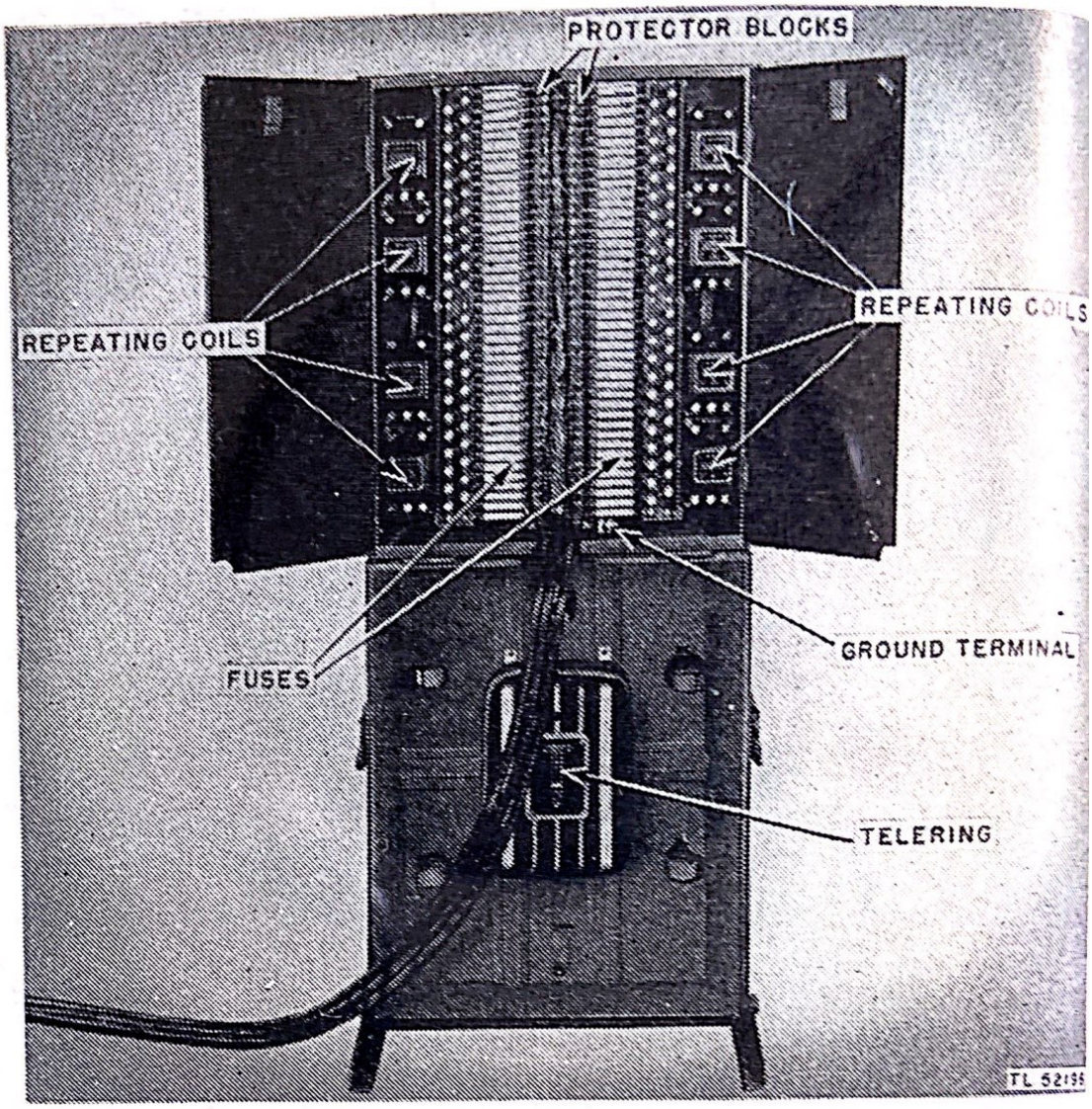


Figure 102. Panel BD–97 ready for operation.

wide by 47 inches high. The switchboard is arranged to be packed within the angle-iron base; no additional packing case is needed for transportation.

(2) *Panel BD–97.* The panel is arranged as shown in figure 102. It consists of 8 repeating Coils C–161, 4 mounted on each side of the cabinet; 2 terminal strips of 44 binding posts each, 1 mounted on each side of the cabinet; 2 vertical rows of 22 pairs of 1-ampere fuses and carbon block arresters mounted in the center of the cabinet; a 20-cycle ringing machine; and 3 rubber-covered cables, each 21 feet long and each consisting of 15 pairs for interconnecting

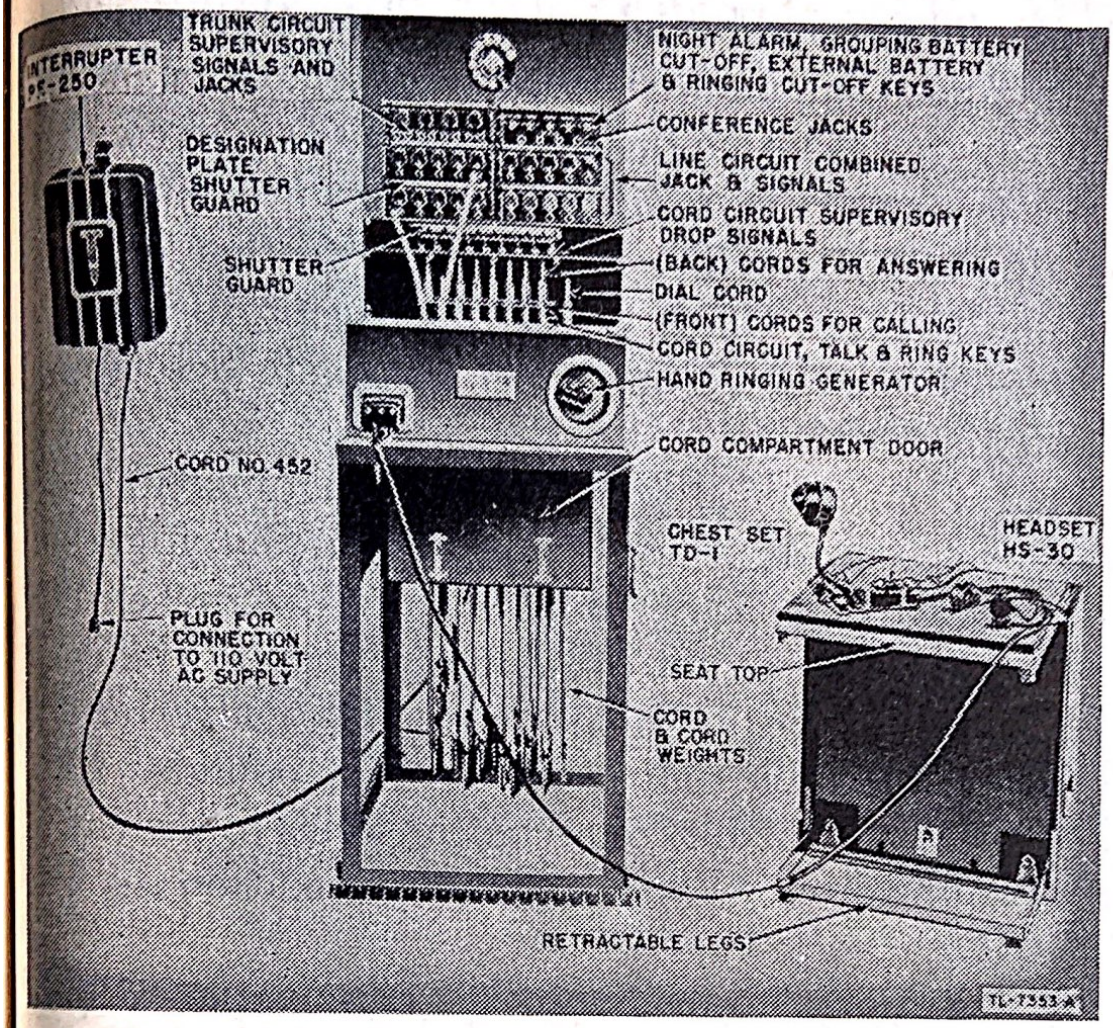


Figure 103. Switchboard BD–91 set up for operation.

Panel BD–97 with Switchboard BD–96. In operating position the panel is approximately 11 inches deep by 24½ inches wide by 55 inches high. A separate packing case is not necessary for transportation. A Protector AR–6 must be used externally to this panel in the line of each circuit using a repeating Coil C–161 in order to provide adequate protection to the coil from lightning and other abnormal currents.

e. Telephone Central Office Set TC–12. (1) This set (fig. 103) comprises a Switchboard BD–91 with self-contained panel and related equipment. The set is for use at division headquarters (other than infan-

try). The switchboard is a complete, transportable single-position, manually operated telephone switchboard. It has 20 magneto line circuits and 4 common battery trunk circuits, manual and automatic. All equipment of the TC–12 is similar to that of Telephone Central Office Set TC–4 except for certain modifications in design. For complete description see TM 11–336.

(2) Converter M–222 is a ringing machine designed to supply 20-cycle ringing current for Telephone Central Office Sets TC–4 and TC–12 when 110-volt, a-c power is not available to operate the component telering-ringing machine. The converter is a complete portable unit weighing 15¼ pounds. Two Batteries BA–23 are connected in series to provide a source of power. For complete information see TM 11–344.

f. Emergency Switchboard SB–18/GT and Adapter Plug U–4/GT. (1) *General.* Emergency Switchboard SB–18/GT consists of Case CY–229/GT, Plug Hold-

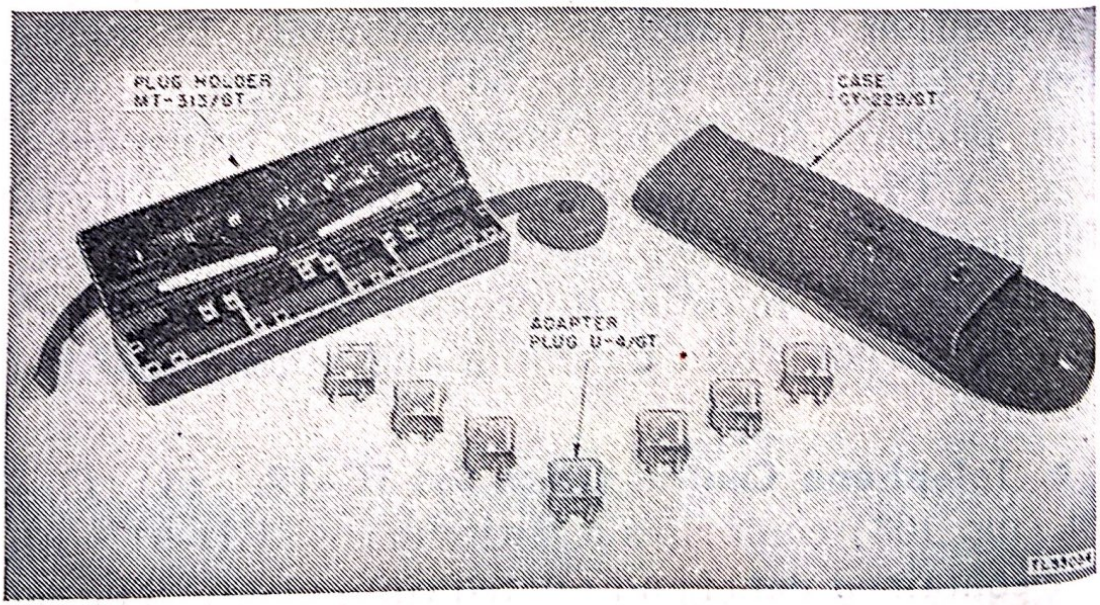


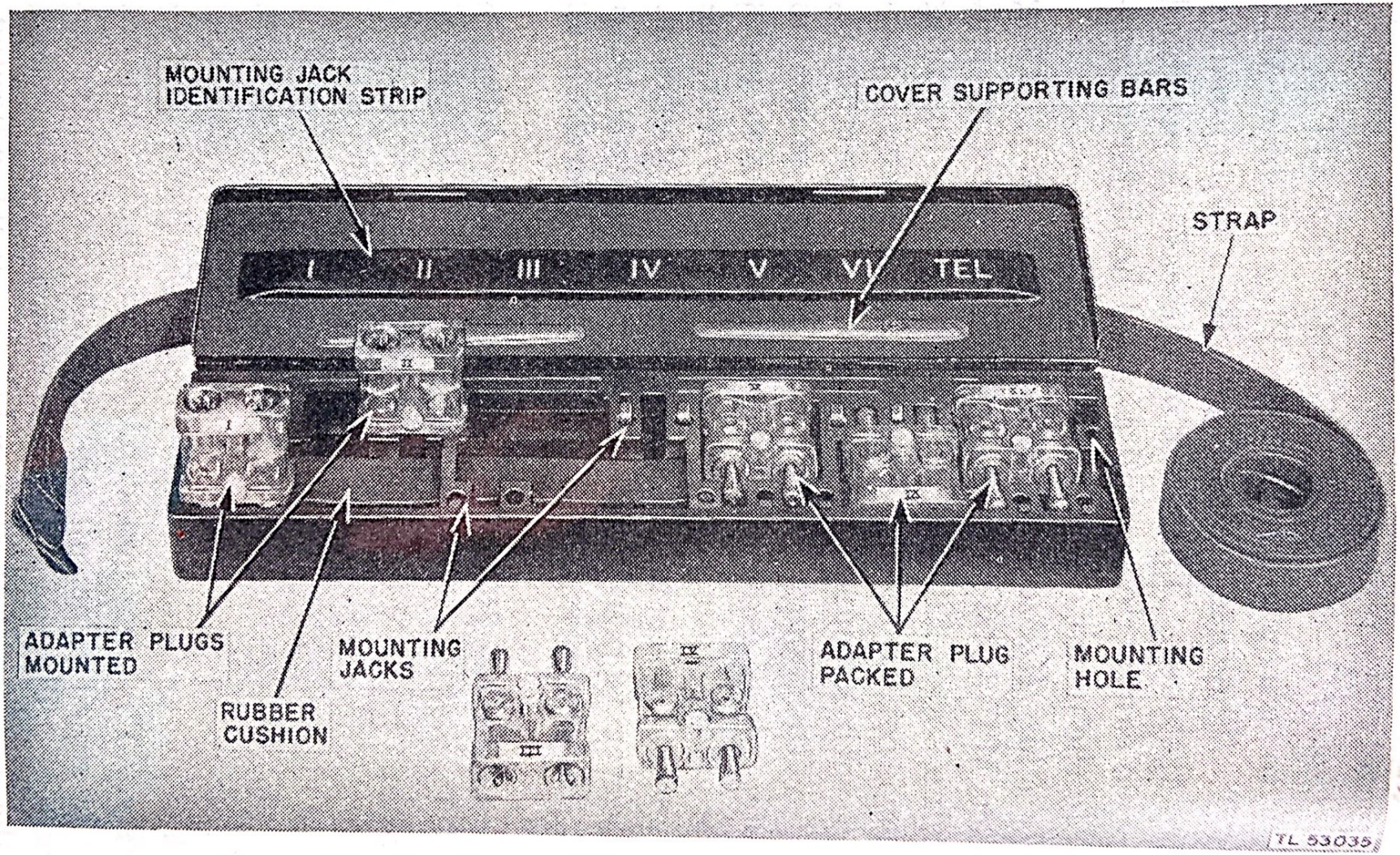
Figure 104. Emergency switchboard SB–18/GT.

er MT–313/GT, and seven Adapter Plugs U–4/GT (fig. 104). Total weight of the complete unit is approximately 2¼ pounds.

(*a*) *Case CY–229/GT.* Case CY–229/GT is designed to carry and protect Plug Holder MT–313/GT. The case is provided with a flap closed by a snap fastener. The back of the case is provided with two canvas loops and a metal hook for attachment to the user's cartridge or pistol belt.

(*b*) *Plug Holder MT–313/GT* (fig. 105). Plug Holder MT–313/GT is designed for mounting and carrying seven Adapter Plugs U–4/GT. The plug holder is constructed of phenolic material and is provided with a hinged metal cover. Compartments, lined with sponge rubber, are used to store the adapter plugs during transportation. Seven jacks in the holder, four in front and three in the rear, are designed to hold the adapter plugs during operation. The cover is provided with an identification strip with luminous numbers to facilitate operation at night.

(*c*) *Adapter Plug U–4/GT* (fig. 106). Adapter Plug U–4/GT is an assembly of two plug-jack combinations mounted in a molded transparent plastic body. The plug ends of the plug-jack combinations act as binding posts for holding the line wires which are inserted through the two bossed holes in line with the plug-jack combinations. The extended plug ends serve as thumbscrews to hold the line wires securely. The plug-jack combinations in the adapters are arranged to permit connection of the adapters in parallel. The mount for the neon lamp is recessed in the center of the body; and the lamp, when lighted,


MOUNTING JACK IDENTIFICATION STRIP
COVER SUPPORTING BARS
STRAP
I
II
III
IV
V
VI
TEL
ADAPTER PLUGS MOUNTED
RUBBER CUSHION
MOUNTING JACKS
ADAPTER PLUG PACKED
MOUNTING HOLE
TL 53039

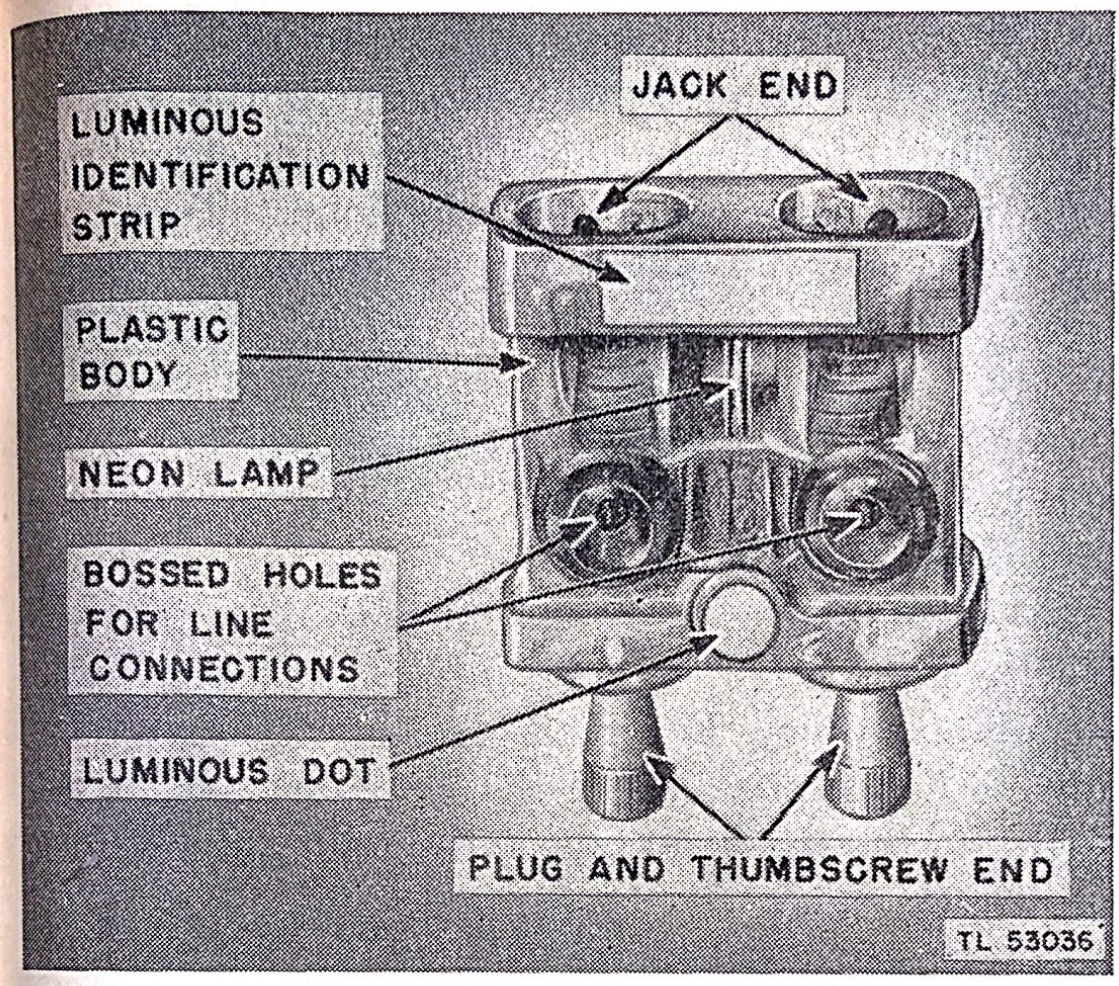


Figure 106. Adapter Plug U–4/GT.

can be seen through the transparent plastic body. Subscribers' names may be written on the luminous strip below. A luminous dot indicates the plug end of the adapter plug, thus facilitating operation in darkness.

(2) *Purpose.* Emergency Switchboard SB–18/GT is a very light, highly mobile, emergency switching center for local battery telephone lines. With Telephone EE–8–( ) or Telephone TP–3 (sound-powered telephone) for an operator's set, Emergency Switchboard SB–18/GT may serve as an emergency field replacement for a magneto switchboard. The small size, weight, and moistureproof characteristics of the SB–18/GT suggest its use in jungle, mountain,

amphibious, and air-borne operations. Adapter Plug U–4/GT also may be used to substitute a silent visual signal for the audible magneto line signal provided in the ringer in either telephone. Telephone EE–8–( ) can operate the signal in Adapter Plug U–4/GT over distances up to 20 miles on Wire W–110–B.

(3) *Testing.* (*a*) Remove 1¼ inches of insulation at a point 6 inches from the ends of a pair of field wires about 4 feet long.

(*b*) Double over and flatten the skinned portions of wire and insert these ends into the bossed holes of the adapter plug. For convenient operation, use the side of the adapter having the luminous strip.

(*c*) Secure the wire ends by tightening the thumbscrew plug ends.

(*d*) Prepare Telephone EE–8–( ) or Telephone TP–3 for use as the operator's set by connecting the other ends of the wire to L1 and L2 binding posts of the telephone.

(*e*) As long as ringng current is applied, the neon lamp will flash.

(*f*) If one of the lamps fails to flash, replace the defective adapter plug with a new one.

Note. Use Chest Set TD–1–A and Headset HS–30–(*) if available rather than the handset of Telephone EE–8–( ), to facilitate handling the adapter plugs.

(4) *Installation.* (*a*) If the preliminary tests have been satisfactory, secure the plug holder cover in place by use of supporting bars provided.

(*b*) Strap the plug holder and Telephone EE–8–( ) to any object which will afford comfortable operation of the switchboard (fig. 107). Keep the equip-

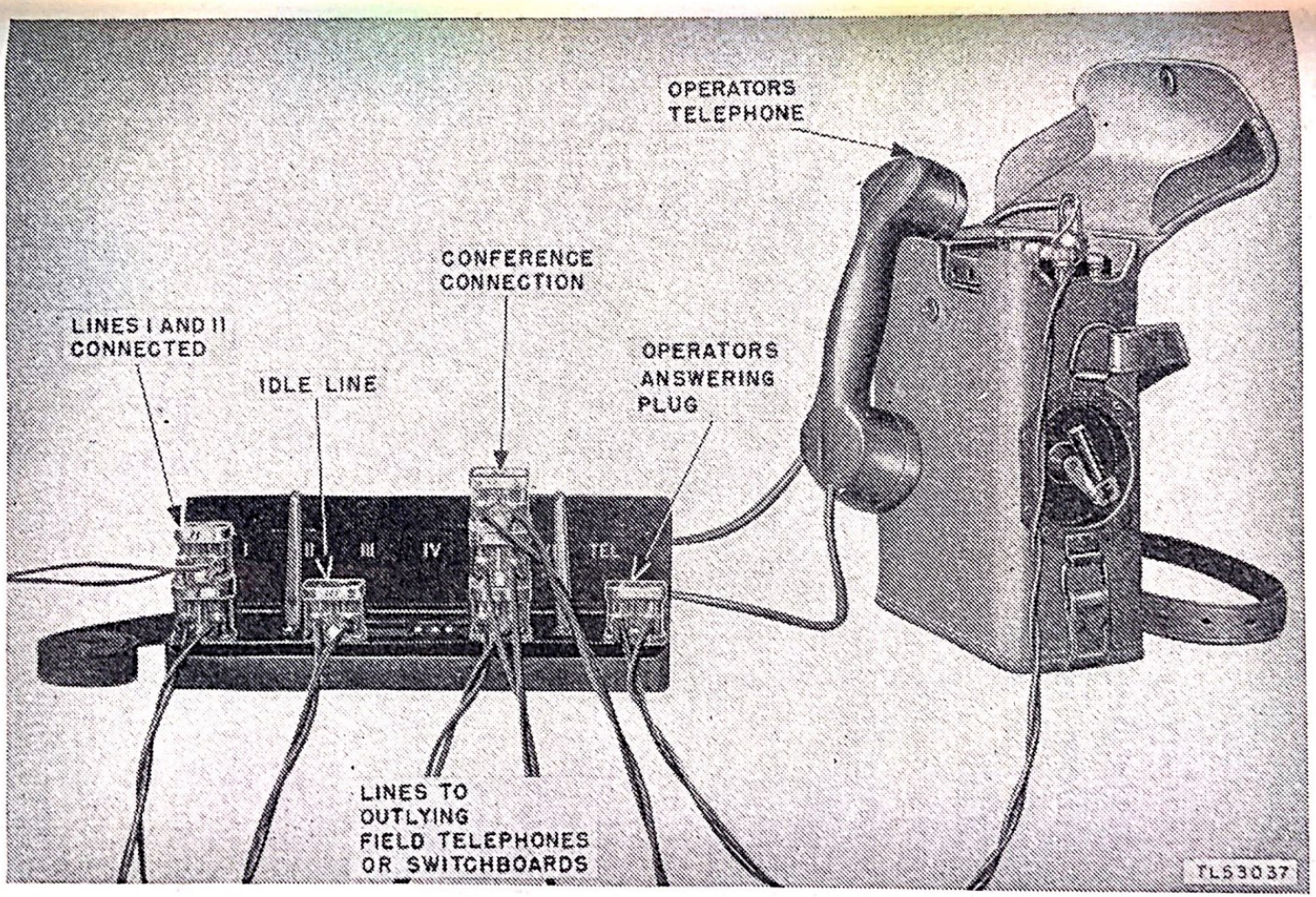


Figure 107. Emergency Switchboard SB–18/GT installed.

ment dry. Moisture will short out the plug and jack combinations.

Caution: When fastening the switchboard to any object, do not allow the entire weight of the switchboard to be supported by the cover.

(5) *Connections.* (*a*) Prepare and connect line wires to adapter plugs. Be sure line wires enter the plugs on the luminous sides only.

(*b*) Allow sufficient slack to form a drip loop and to permit free movement of the adapter.

(*c*) Mark each adapter with Roman numerals (using a soft black pencil) to correspond with marking on plug holder.

(*d*) Place adapters in the mounting jacks corresponding to the line numbers on the adapters. Keep the luminous side of the adapter toward the operator.

(6) *Connection for silent visual signal for telephone* (figs. 108). To substitute a silent visual signal for the ringer in Telephone EE–8–( ), disconnect the ringer and connect the adapter across line terminals L1 and L2 of the telephone. See TM 11–333 for this procedure. The adapter may be connected in either of two ways—

(*a*) Remove 1½ inches of insulation at a point 1 foot or more from the end of the line wire. Double over the skinned sections and connect the line to line terminals L1 and L2 of the telephone. Remove 1¼ inches of insulation at a point 6 inches from the ends of the line wires. Double over the skinned sections and insert them in the bossed holes in the adapter plug. Tighten the thumbscrew.

(*b*) Connect the line wires to line terminals L1 and L2 of the telephone. Attach the adapter plug to a

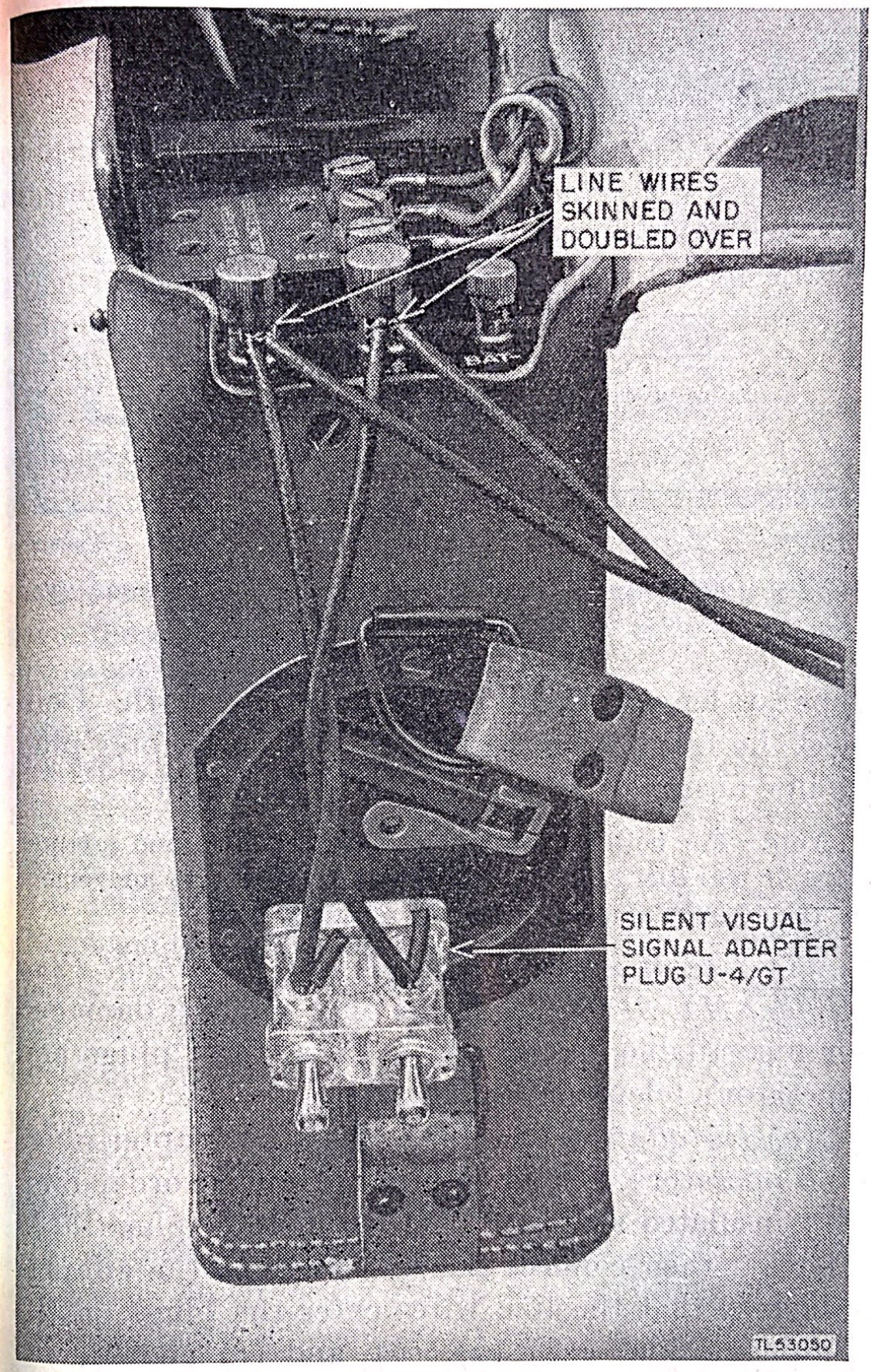


Figure 108. Adapter Plug U–4/GT, used as a silent ringer on Telephone EE–8–( ).

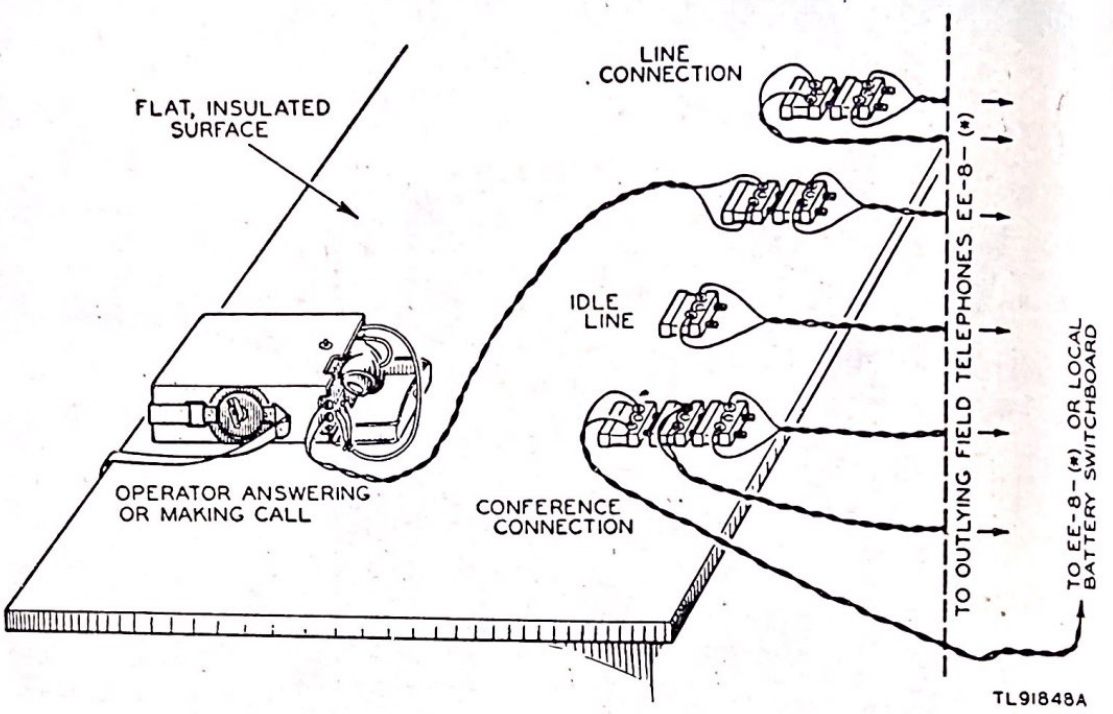


Figure 109. Adapter Plugs U–4/GT, in use without Plug Holder MT–313/GT.

separate length of wire 1 foot or more in length. Connect the free ends of the wire from the adapter plug to line terminals L1 and L2 of the telephone.

Note. For both methods place the telephone and adapter plug in parallel. Allow sufficient slack for free movement of the adapter and for formation of a drip loop.

(7) *Use of Adapter Plug U–4/GT without Plug Holder MT–313/GT.* If the plug holder is damaged or unavailable, operate with the adapter plugs and operator's telephone as follows:

(*a*) *Installation* (fig. 109). Lay the adapter plugs and operator's telephone in a convenient order on a dry insulated surface. Test the adapter plugs ((3) above); then connect the line wires to the adapter plugs so that the line wires enter the plugs on the luminous sides ((3) (*a*), (*b*), and (*c*) above).

(*b*) *Operation.* Operate as described in paragraph 55**c**.

45. INSTALLATION OF TELEPHONE CENTRALS. a. General. Installation of a field telephone central includes installing the switchboard and its auxiliary equipment; terminal strips, if required; testing equipment, if available; and local circuits and telephones (except long locals). It also includes making the proper connections at the switchboard terminal strip between local circuits and trunk circuits turned over by construction teams.

b. Records. Each circuit is tested as soon as it is connected. When the circuit is in satisfactory operating condition, the time is recorded and the message center is informed of the available service. A traffic diagram (par. 62) is prepared and posted at the switchboard, together with a copy of the telephone directory for the use of the operator.

c. Temporary service. Trunk circuits that are available before the switchboard is installed are connected directly to telephones to give temporary service.

d. Improving location of circuits. After the telephone central is installed and operating, circuits should be arranged for better protection and for aid in maintaining a line. Circuits emerging from a telephone central are placed either overhead or underground so they will not be subject to interference from troops and traffic in the vicinity of the command post.

e. Priority for installing telephone. (1) The sequence in which local circuits at a telephone central are installed is determined by established priorities. Normally the circuits are installed in the following order for ground force units:

(*a*) Message center.
(*b*) Operation section (G–3 or S–3).
(*c*) Commander (or chief of staff, or executive).
(*d*) Intelligence section (G–2 or S–2).
(*e*) Supply section (G–4 or S–4).
(*f*) Signal section (signal or communication officer).
(*g*) Personnel section (G–1 or S–1).

(2) Other local telephones are installed as required for other activities as soon as possible after the units set up operations in the command post area. A public telephone, installed in a convenient location and at the earliest practicable time, is available for staff personnel until the telephone for their staff section has been installed. This telephone is available also for the official use of all other personnel not authorized individual telephones.

f. Use of telephones. At command posts of small units, as in battalions or regiments, one telephone ordinarily serves two or more staff officers. At larger headquarters, more than one telephone may be installed in each staff section. All echelons telephone requirements are reduced to a minimum.

46. INSTALLATION OF TELEPHONE SWITCHBOARDS.

a. General. A field telephone central may include one or more switchboards, depending on the number of trunk and local circuits to be installed. With certain types of switchboards, it is necessary to install terminal strips; with others, the terminal strips and the repeating coils are contained in the switchboard itself. The board and its associated equipment are installed in a centrally located place with as much shelter, concealment, and freedom from noise and

interference as possible. Provide cover from enemy fire at the earliest practicable moment. Frequently it is convenient, particularly in rapidly moving situations, to install switchboards in vehicles. However, except in armored units, telephone switchboards must not be permanently mounted in vehicles.

b. Switchboards BD–72 and BD–71. See TM 11–330.

c. Switchboard SB–5/PT. See TM 11–2016.

d. Telephone Central Office Set TC–4. See TM 11–332.

e. Telephone Central Office Set TC–12. See TM 11–336.

47. CONVERSION OF TEST STATIONS TO TELEPHONE CENTRALS. **a.** When a command post is established where a test station has been installed previously, the test station can be converted easily into a telephone central. At a test station that is to be converted into a telephone central, lines will be placed overhead. If it becomes necessary to use a test station not designated as a probable future telephone central, run the circuits overhead before the conversion takes place.

b. The switchboard is set up as near the test station as possible in order to facilitate the cut-over. The two switchboard units to which the two sections of the circuit are to be connected are plugged through to each other. The sections of the circuit being cut over are interconnected around the terminal strips of the test station by means of test leads equipped with clips. With the circuit bridged around the terminal strip, it may be removed from the test station and installed in the main frame or terminal

strip of the switching central. Remove test clips quickly to prevent any possible cross on the line. The remaining circuits are transferred in like manner.

c. When the transfer is completed, the operator listens in on each circuit that enters the switchboard and, if the circuit is not busy, removes the patching connection. The operator then calls over each circuit and informs the answering operator that the test station has been converted into a telephone central, at the same time giving directory names and any other pertinent information.

48. INSTALLATION OF TELEPHONES. a. General. Both common battery and local battery telephones are used in field wire systems, sometimes in the same installation. Within divisions, however, the instruments are local battery (magneto). Telephones should be installed in positions convenient to users; the field wire connections should be tied in near the instrument, and sufficient slack should be left between the tie and the instrument to permit some movement of the telephone. If the circuit enters the place of installation from overhead, a drip loop is inserted to drain water away from the instrument (fig. 29). If the telephone is strapped to a tree trunk or tent pole, tie down the instrument firmly with a short length of field wire in a manner providing easy access to the handset and generator crank. Attach to each telephone the telephone directory tag (par. 63e) and a tag bearing the directory name and number of that telephone. When an installation has been tested and is completed, inform the user immediately of that fact.

b. Telephone EE–8–A and EE–8–B. (1) *Installation.* Place two Batteries BA–30 in the compartment under the lever switch. This compartment is accessible when the handset is removed from the case. Make certain that the bottoms of the batteries rest on the springs and that the brass caps rest securely on the contacts at the top of the battery compartment. Connect the field wire conductors to binding posts L1 and L2.

(2) *Local battery operation.* (*a*) *To signal*, turn the generator rapidly for several turns.

(*b*) *To talk and listen*, hold the handset with the receiver to the ear. While talking, operate the handset switch with the thumb and talk directly into the transmitter. When listening, release the switch. This conserves battery strength, eliminates outside noises originating near the telephone, and minimizes electrical losses in the transmitter.

(*c*) *To ring off*, turn the generator rapidly for several turns. This indicates to the switchboard operator that the conversation is ended or that a new connection is desired. After ringing off, replace the handset in the case if a new connection is not desired. Let the cord hang out.

(*d*) Communicating through a gas mask will be necessary under conditions of gas warfare. The decrease in intelligibility of a telephone conversation through a gas mask can be partially overcome by holding the transmitter directly in front of and close to the speech diaphragm of the *diaphragm-type* gas mask or the outlet valve of the *service-type* gas mask while talking. Holding the transmitter in this position may cause the receiver to be moved away from

the ear. In this case, the person at the other end of the line must be informed that a gas mask is being worn by the speaker and that the speaker will use the procedure word *over* each time he has finished talking to indicate that he is ready to listen. This procedure prevents the person at the distant end from speaking when he cannot be heard by the person wearing the gas mask. A more positive method of overcoming low intelligibility when wearing the gas mask is to use a lip microphone (Microphone T–45) or a throat microphone (Microphone T–30). Microphones T–45 and T–30 are designed to plug into the jack on Chest Set TD–3. Chest Set TD–3 can be plugged into the receptacle jack on Telephone EE–8–( ). The lip microphone must be adjusted to the wearer prior to donning the mask. The throat microphone requires more careful adjustment for good intelligibility. Chest Sets TD–1 and TD–2 are equipped with chest microphones. Conversion of Chest Sets TD–1 and TD–2 for use with Microphones T–30 and T–45 may be made. Information for making this conversion is contained in MWO SIG 19, Modification of Chest Sets TD–1 and TD–2 to Permit Use of Microphones T–30 and T–45, November 1944. Telephone EE–8–( ) may be used with Microphones T–30 and T–45 (without Chest Set TD–1, TD2, or TD–3) by connecting as follows:

1. Solder the two conductors of a 6-foot piece of wire (Wire W–110–B or equivalent) to the pins of Plug PL–291 or PL–291–A of the microphone. Tape securely.

2. Connect the other end of the wire under the T and C terminal screws on Telephone EE–8–( ).

Note. Since there is no switch provided for connecting Microphones T–30 and T–45 with Telephone EE–8–( ) on this wire, microphone current flows as long as the cord is connected to the telephone terminals. Therefore, disconnect the cord when the microphone is not needed for immediate use.

3. If Cordage CO–219 is available, use it for emergency connection of Microphones T–30 and T–45 with Telephone EE–8–( ). The use of Jack JK–48 permits the microphones to be easily connected and disconnected from Cordage CO–219. Leave Cordage CO–219 permanently connected to the T and C terminals on Telephone EE–8–( ). Pull out Jack JK–48 when through using the telephone to conserve battery current.

4. When the threat of gas warfare passes, restore the modified chest sets and microphone plugs to their original state.

(3) *Common battery operation.* Turn the screw switch, near the lever switch, clockwise with a screw driver until it comes to a stop. The lever switch (fig. 110) is an essential part of the telephone in common battery operation, corresponding to the hook or plunger switch on commercial telephones. When not in use, the handset is placed with the transmitter up resting upon and depressing the lever switch.

(*a*) *To call*, remove the handset from its position on the lever switch. (The lever switch is then released, as shown by the dotted lines in figure 110.)

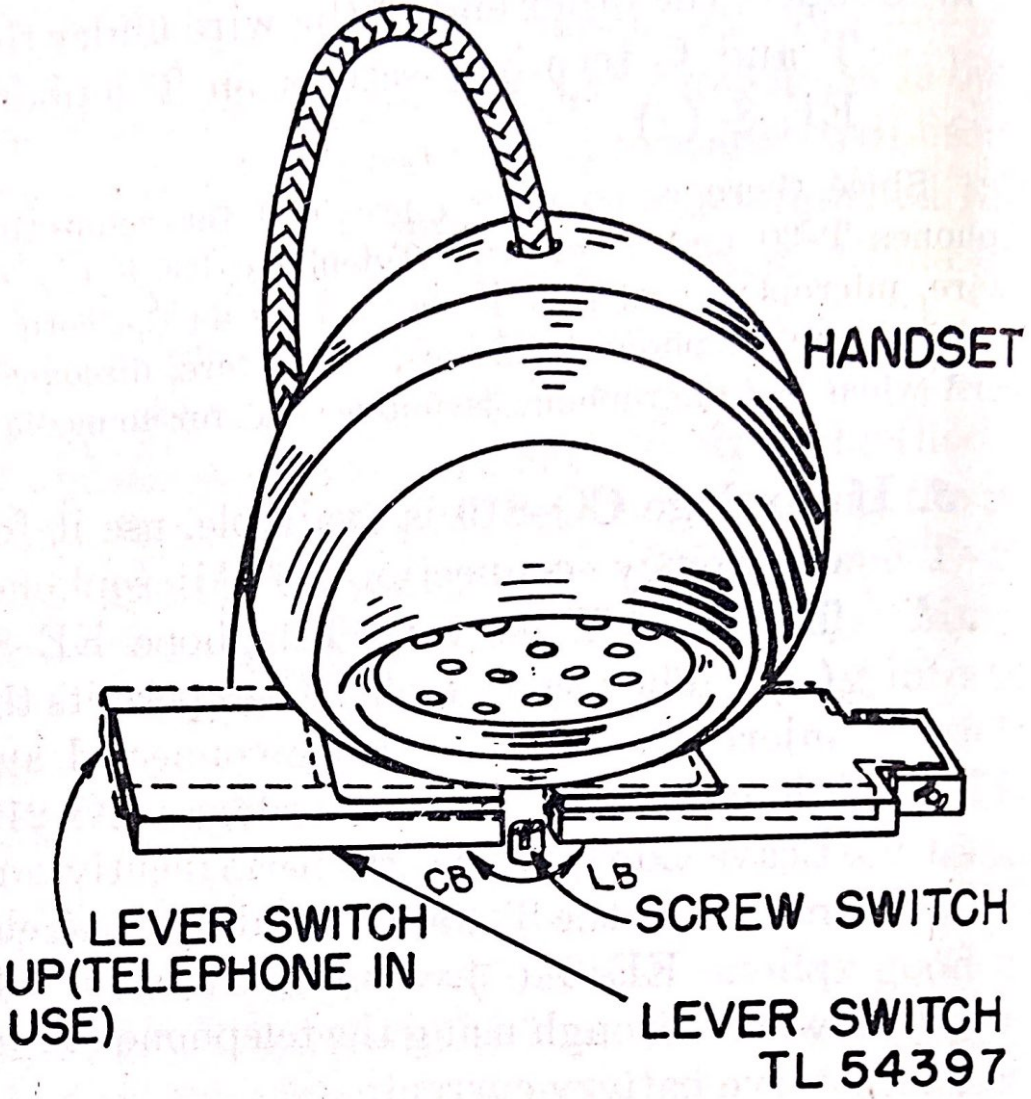


Figure 110. Position of handset lever switch in common battery operation.

If the switchboard operator does not answer, depress and release the lever switch *slowly* several times. This flashes the line lamp at the switchboard, giving notice to the operator. *DO NOT* turn the generator crank as this may burn out the line lamp at the switchboard. Generator cranks can be tapped so as to prevent their use.

(*b*) *To talk and listen*, proceed as in (2) (*b*) above. Batteries BA–30 furnish talking current for common battery as well as for local battery operation.

(*c*) *To recall the operator*, push the lever switch down and release *slowly* several times.

(*d*) *To indicate completion of call*, replace the handset, depressing the lever switch.

(*e*) *To close station*, the person removing the telephone should flash the telephone central operator or other party on the line before disconnecting the telephone and inform him that the telephone is being removed from the circuit. Remove the connections to L1 and L2. Remove Batteries BA–30 unless the telephone is to be installed on another circuit immediately. Highly corrosive chemicals which can damage the telephone leak out of run-down batteries. Fold the rubber-covered cord loosely into folds about as long as the handset, place the folds alongside the handset, and insert the handset (receiver end first) into the case. The cord also may be handled conveniently by holding the handset in the left hand, placing the thumb against the receiver case, and wrapping the cord in long folds completely around the handset. In either case, *do not wrap the cord around the handle of the handset* because this will damage the cord and may operate the handset switch. The switch must be left in the neutral position (wings parallel to the handle) to prevent rapid running down of the batteries when the batteries are left in the instrument.

49. TELEPHONE REPEATER EE–89–( ). Telephone Repeater EE–89–( ) is used to give improved transmission and to extend the voice-frequency talking range. It is a 21-type repeater. Two-wire transmission is used; that is, the same pair is used for transmission in both directions. This repeater is for use as an intermediate repeater, and for best results it should be located approximately in the center of the

line so that the equipment on either side of the repeater will have similar characteristics. Normal simplex telegraph operation and 20-cycle ringing are possible over lines equipped with one or more of these repeaters. For information on installation, operation, and maintenance of this equipment see TM 11–2006.

50. REPEATING COILS. a. General. Repeating coils are used in field wire systems to make possible the construction of simplex and phantom circuits for additional teletypewriter or telephone channels. The coils consist of two windings on a magnetic core, carefully balanced to prevent cross talk. The ends of one winding are brought out to two terminals marked LINE that are connected to the incoming wire line. The ends of the other winding are brought out to two terminals marked SWITCHBOARD that are connected to the switchboard line terminals. The midpoint of the line side of the coil is brought out to a fifth terminal, marked TELEG, that can be connected to provide a simplex or phantom circuit (pars. 51 and 52).

b. Type. The coil commonly issued for use in the field is Coil C–161 (fig. 111).

c. Test. To test repeating coils, connect the coil under test to a good coil; use a short length of wire and connect the coil in the manner shown in figure 112 for simplexing a line. The ground should be an actual wire connection for this test. Then connect four serviceable telephones to the two coils; one pair of telephones to the metallic circuit and one pair of telephones to the simplex circuit which is completed through the wire replacing the ground return cir-

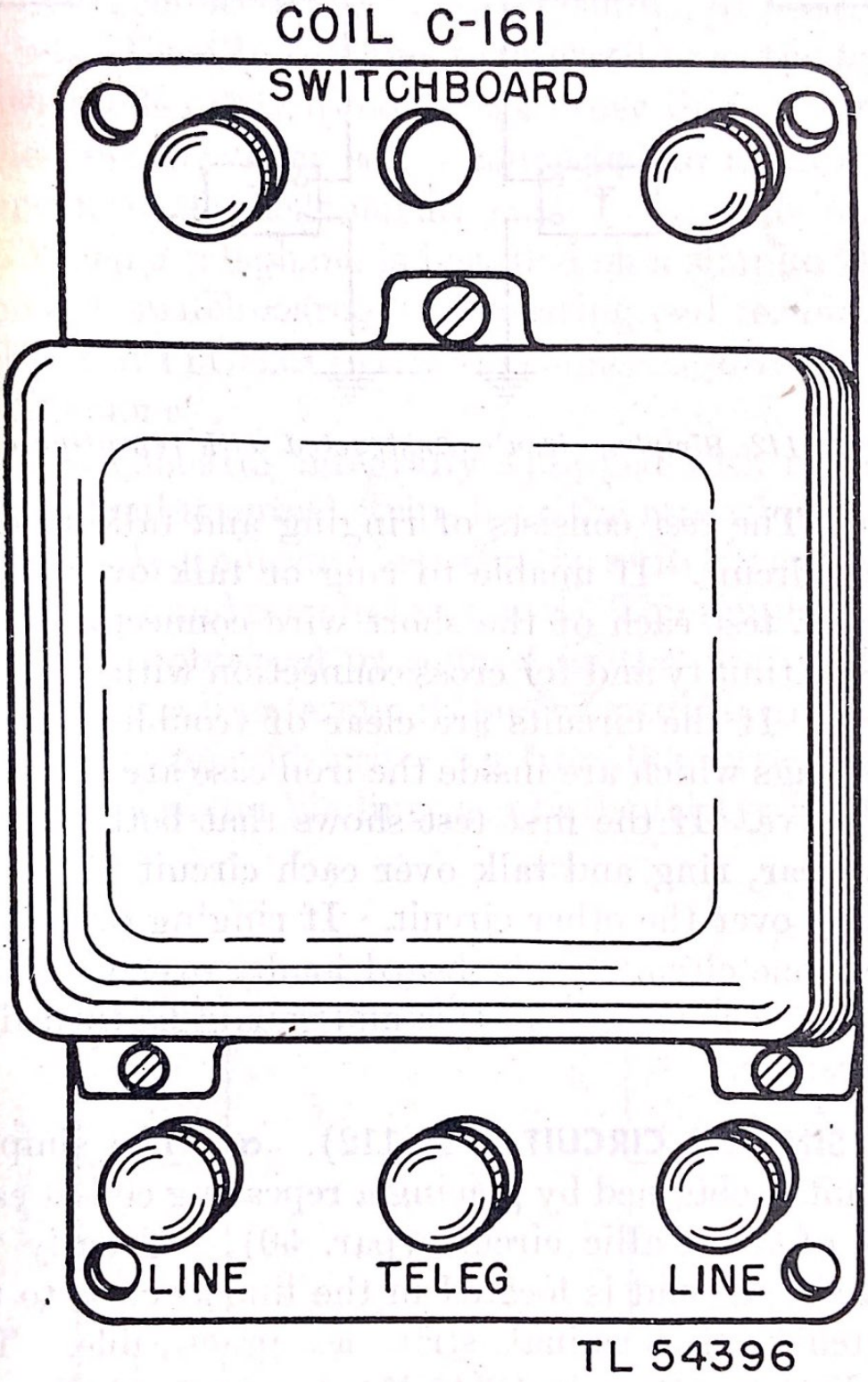


Figure 111. Coil C–161 (repeating)

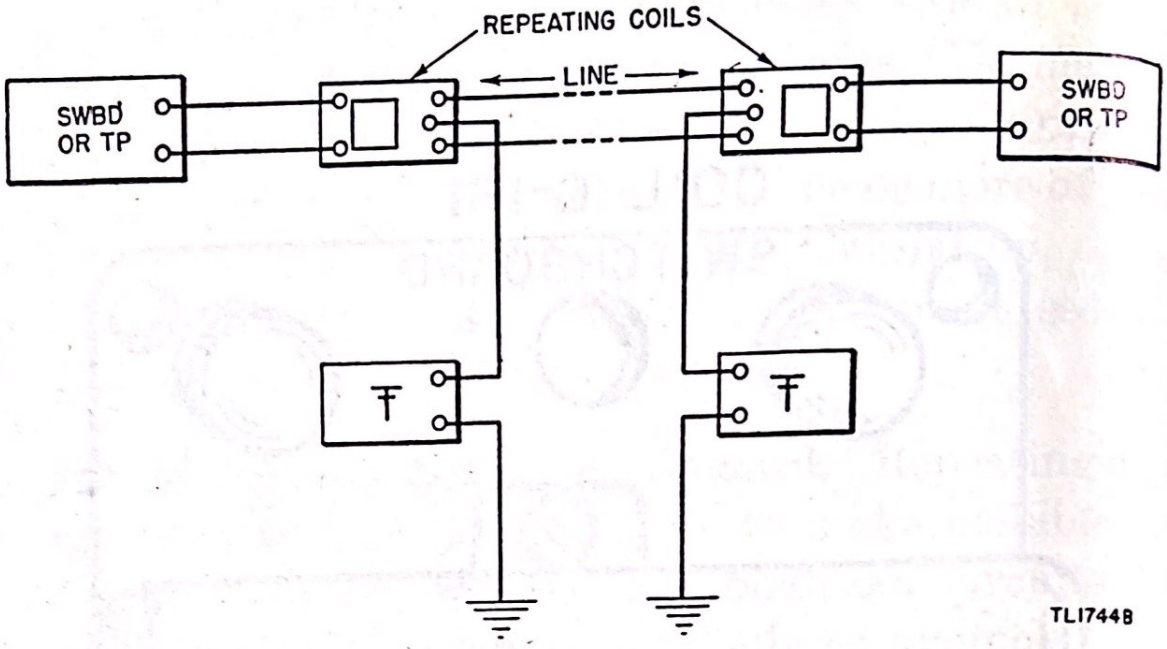


Figure 112. Simplex circuit constructed with repeating coils.

cuit. The test consists of ringing and talking over each circuit. If unable to ring or talk over either circuit, test each of the short wire connectors, both for continuity and for cross connection with all other wires. If the circuits are clear of trouble, the coil windings which are inside the iron case are probably defective. If the first test shows that both circuits are clear, ring and talk over each circuit while listening over the other circuit. If ringing or talking over one circuit can be heard loudly over the other circuit, the coil is defective and should be turned in for repair.

51. SIMPLEX CIRCUIT (fig. 112). **a.** The simplex circuit is obtained by placing a repeating coil at each end of a metallic circuit (par. 50). Usually the coil at each end is located in the line as close to the switchboard terminal strip as practicable. The binding posts marked LINE are connected directly to the line, and those marked SWITCHBOARD are connected to the desired line terminals on the switch-

board. The telephone circuit is completed inductively through the coil. The binding post marked TELEG is connected to one line terminal of the teletype set. Usually this line is referred to as the teletypewriter leg. Ordinarily the other line terminal of the teletypewriter set is connected to a suitable ground near the instrument.

b. When a telephone is installed on a simplex line without a switchboard, the repeating coil terminals marked SWITCHBOARD are connected directly to the telephone.

c. Switchboards integrally equipped with repeating coils and terminal strips have the repeating coils permanently connected between the switchboard terminal strips and certain line units. The simplex circuit is then obtained by connecting the desired line to the proper line terminals on the switchboard and running the teletypewriter leg from the corresponding teletypewriter binding post to the teletypewriter set.

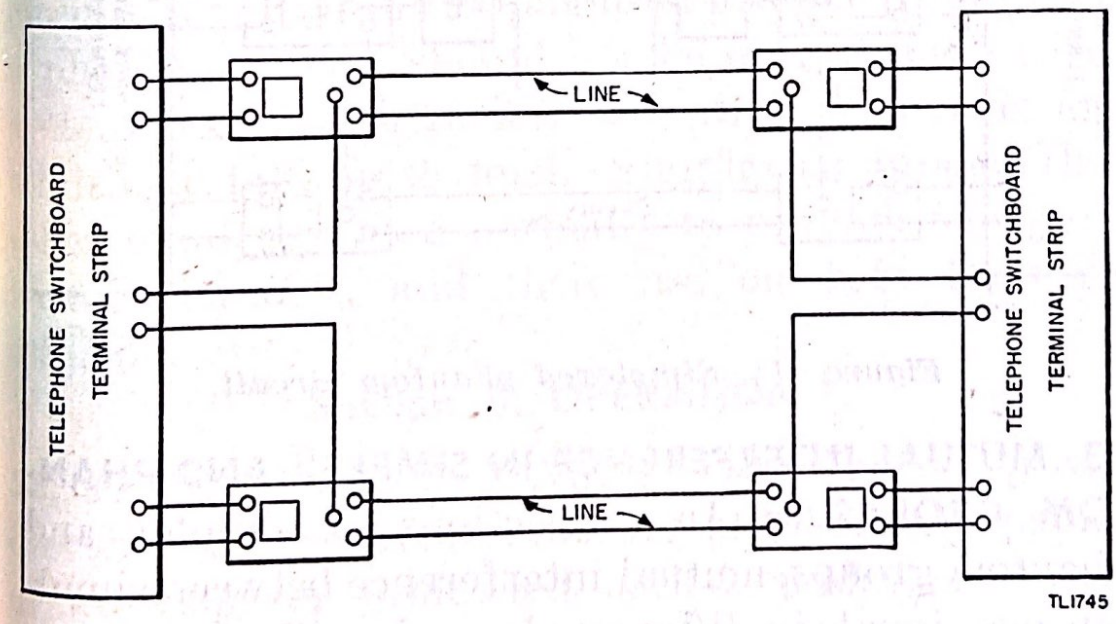


Figure 113. Phantom circuit constructed with repeating coils.

52. PHANTOM CIRCUIT. a. A phantom circuit (fig. 113) may be constructed from two metallic circuits and four repeating coils, one at each end of the metallic circuits. Except for the teletypewriter legs the coils are connected as in paragraph 51. The two binding posts marked TELEG at each end of the lines form the phantom circuit and may be connected to an unused pair of line terminals at the switchboard.

b. If desired, the phantom circuit thus formed may be simplexed itself to obtain a teletypewriter circuit in the same manner as described in paragraph 51 for a single metallic circuit. This requires the use of an additional repeating coil at each end of the phantom circuit (fig. 114).

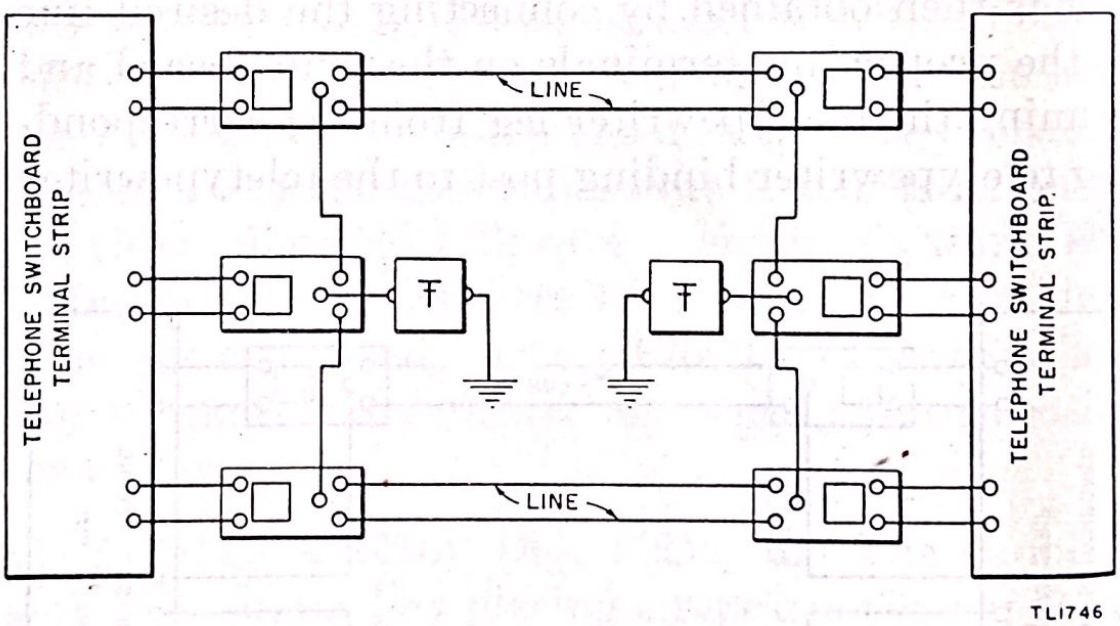


Figure 114. Simplexed phantom circuit.

53. MUTUAL INTERFERENCE IN SIMPLEX AND PHANTOM GROUPS. a. In connections of simplex and phantom groups, mutual interference between simultaneous signals in different channels will result when all wires in the simplex or phantom group do not

have exactly the same impedance. The circuits then are said to be unbalanced, and the amount of the interference will depend upon the degree of unbalance between the two physical (metallic) circuits. The primary causes are poor splices, which introduce a high resistance into either side of the circuit, and improperly taped splices or damaged insulation which, particularly when the line is wet, results in excessive leakage from one side of the circuit to ground. Although it is impossible to obtain a perfect impedance balance in field wire circuits, mutual interference may be reduced to a negligible value by making certain that each wire of a group is of approximately the same length and that all splices are well made. In addition, overhead construction at low, wet places and during rainy weather will assist in reducing interference.

b. Usually the interference resulting from any unbalance is more pronounced in a phantom group than in a simplex circuit, because there are more circuits involved in the phantom group. Therefore, a phantom circuit should not be used in field wire systems except where it is essential to provide an additional talking channel. Simplex circuits, on the other hand, are used normally to provide teletypewriter channels, and their use on field lines is common.

Section II. OPERATION

54. SWITCHBOARD OPERATOR. Switchboard operators should be courteous, intelligent, efficient, capable of working for prolonged periods under pressure, able to speak distinctly, and able to understand speech readily over the telephone. They should be

familiar with army organization. Switchboard operators can be of great assistance to the wire chief by keeping him informed of the conditions of the circuits.

55. SWITCHBOARD OPERATION. a. Switchboard BD–72 and BD–71. Switchboard BD–72 is a 12-line switchboard and Switchboard BD–71 is a 6-line switchboard; both are used in small units. These boards are similar in operation and are capable of handling conference calls as well as regular calls. For further information on the operation of Switchboards BD–72 and BD–71 see TM 11–330.

b. Switchboard BD–96. Switchboard BD–96 has 40 line circuits, magneto, 12-cord circuits, and 4 common battery trunk circuits (manual and automatic) and is an integral part of Telephone Central TC–4 along with Panel BD–97. The operation of this switchboard is similar to that of comparable commercial switchboards. In addition to incoming and outgoing calls, this board is capable of handling conference calls, dial trunk calls, common battery manual trunk calls, and complete supervision. For further information on the operation of Switchboard BD–96 see TM 11–332.

c. Emergency Switchboard SB–18/GT. Emergency Switchboard SB–18/GT is designed for emergency use only. Its operation is as follows:

(1) *Line-to-line connection.* (*a*) When the neon lamp flashes in a calling party's adapter plug, insert the operator's adapter plug into the jack of the calling party's adapter plug. Answer the calling party by use of the operator's telephone.

(*b*) After determining the number to be called, remove the operator's adapter from the calling party's jack and insert it into the jack of the called party's adapter plug.

(*c*) Ring the called party with the operator's hand generator.

(*d*) When the called party answers, connect the called party to the calling party and report the connection ready.

(*e*) Do not remove the operator's adapter until conversation has begun.

(*f*) To supervise any connection, insert the operator's adapter into the called party's adapter.

(*g*) A recall or ring-off will be denoted by the neon lamp flashing on both adapters.

(2) *Conference connection.* (*a*) To set up a conference connection use the operator's adapter plug to call each party individually.

(*b*) Inform the called parties to stand by for a conference call and connect each adapter in parallel.

(*c*) After all the desired parties are connected, inform the calling party that the conference is established.

(*d*) On a recall by any party in the conference connection, the neon lamps of all the line plugs connected will flash.

(*e*) Supervise the connection on a recall or ring-off, challenge, and disconnect or change the connection as desired.

56. OPERATING PHRASES. a. The following phrases are prescribed for use by switchboard operators in all cases where they apply, to the exclusion of other phrases of similar meaning:

(1) "Magic Operator." Used by an operator in answering a call at the switchboard of the unit whose directory name is Magic.

(2) "Magic ——." (Blank is appropriate directory number.) Used by an operator to indicate that he has understood correctly a number given to him either by a local party or by an operator of another telephone central and that he is proceeding to complete the call.

(3) "What number please?" Used by an operator to request repetition of a number which he has not understood.

(4) "The line is busy." Used by an operator to report that a local telephone for which he has received a call is already in use.

(5) "Maytime is busy." Used by an operator who has received a call intended for a certain telephone central (Maytime) to report that all trunks to the central are in use.

(6) "Magic three–three does not answer." Used by an operator to report that a called party (Magic three–three) does not answer.

(7) "Maytime does not answer." Used by an operator to report that a certain called telephone central (Maytime) does not answer.

(8) "Here's your party." Used by an operator to notify the calling party that a connection is complete and that conversation may begin.

(9) "Have you finished?" Used by an operator in supervising a connection when no conversation is heard. Repeat the challenge if no reply is heard.

(10) "I will ring again." Used by an operator when, in supervising a connection, he is informed that the called party did not answer.

(11) "What number is calling, please?" Used by an operator if, after supervising a connection, he is given a new number to call by one of the parties but is unable to identify the party.

(12) "Magic three–zero has no telephone, but I can give you Magic one–one." Used by an operator when there is no telephone for the number called but another telephone is available to which the calling party may wish to be connected.

(13) "What number were you calling, please?" Used by an operator to determine the number desired by a party who reports he has been given a wrong number or has been cut off.

(14) "One moment, please" or "I have a call for you." Used by an operator, if necessary, to hold either party on the line while a connection is being completed.

(15) "Calling Magic" or "Calling Magic one–one." Used by an operator when there is confusion or interruption in getting an operator or called party on the line.

b. The following words and phrases are prescribed for use by telephone users in all cases where they apply, to the exclusion of other phrases of similar meaning:

Words and phrases	*Meaning*
(1) Acknowledge	Used between originator and addressee: "Let me know that you have received and understand this message."

Words and phrases	*Meaning*
(2) All after-------	Used in conjunction with verification, repetition, and correction to indicate portion of message.
(3) All before------	Used in conjunction with verification, repetition, and correction to indicate portion of message.
(4) Break----------	"I hereby indicate the separation of the text from other portions of the message." To be used when there is no clear distinction between text and other portions of the message.
(5) Correction------	"An error has been made in this transmission (or message indicated). The correct version is ---------."
(6) Disregard this transmission.	To be followed by "out" and means, "This transmission is in error. Disregard it." (Must NOT be used to CANCEL any message that has been COMPLETELY TRANSMITTED.)
(7) I say again----	To be used in response to a request for a repeat.
(8) I spell---------	"I spell."
(9) Out------------	"This is the end of my transmission to you and no answer is required or expected."
(10) Over----------	"Go ahead; transmit. This is the end of my transmission to you and a response is necessary."
(11) Relay to------	"Transmit this message to the station indicated."
(12) Roger---------	"I have received your last message."
(13) Say again-----	"Say again all of your last transmission." Followed by identification data means "Say again message or portions indicated."
(14) Send your message.	"Send your message."

Words and phrases	*Meaning*
(15) Speak slower--	"Speak slower."
(16) Stand by to write.	"A message which will require a permanent record is about to follow."
(17) This is correct-	"You are correct."
(18) This is--------	"This transmission is from the station whose call sign or other identification follows."
(19) Time----------	Used as a prefix to the time or date-time group of message being transmitted.
(20) Verify---------	"Verify entire message (or portion indicated) with the originator, check cryptographing, and send correct version."
(21) Wait---------- or Wait Out	If used alone: "I must pause for a few seconds." If the pause is to be longer than a few seconds, "Wait-Out" should be used.
(22) Wilco---------	Used between addressee and originator only: "Your last message (or message indicated) received, understood, and will be complied with."
(23) Word after----	Used in conjunction with verification, repetition, and correction to indicate portion of message.
(24) Wrong---------	"What you have just said is incorrect. The correct version is --------."
(25) Execute-------	"Carry out the purport of the message or signal to which this applies."
(26) Execute to follow.	"Action on the message or signal which follows is to be initiated upon receipt of the procedure word 'Execute.'"
(27) Stand by------	"Wait for the word 'Execute.'"

57. SUPERVISION. a. New connection. A switchboard operator supervises each connection to make certain that conversation is established between the calling party and the called party and to remove the connection as soon as possible after the conversation is completed. The operator listens in after he has made a connection and rung the called party, waiting to hear the called party answer and conversation begin. He remains connected with the trunk call to another telephone central until that central has answered and he has passed the call on. If it is necessary for the operator to answer another call before he has supervised a connection, he does so and then completes the supervision at the first opportunity. A shutter is never restored on a connection until it has been supervised.

b. Established connection. If the operator does not hear any conversation when supervising a connection which has already been established, he challenges by asking "Have you finished?" Great care is taken not to interrupt a conversation in progress. If, after a second challenge, he receives no response, he takes down the connection. Connections are supervised frequently in this manner in case both parties may have failed to ring off when the conversation was completed. If the operator is notified that the called party has not answered, he answers "I will ring again," and does so. If he is informed that the connection is still in use, he restores his listening key to the normal (mid) position.

c. Completed calls. Normally when a conversation is completed the drop on the connection will fall be-

cause of one of the parties ringing off. This is the signal for the operator to supervise the connection in the manner described in **b** above. If a new number is given him by either party, he asks "What number is calling, please?" and proceeds to complete the call in the usual manner.

58. TELEPHONE CONVERSATIONS. a. Placing calls. In placing a telephone call, the complete designation of the party desired is given to the switchboard operator (directory name of the unit and directory number of the party). However, in placing a call to a party at the same headquarters or echelon as that served by the switchboard, it is not necessary to give the directory name of the unit.

b. Answering calls. In answering a telephone call, the expression "Hello" should *not* be used. The person answering the call states the directory name and number of the telephone and identifies himself. For example "Magic three, S–3 speaking."

c. Brevity and security. Telephone conversations should be kept as brief as possible so as not to deprive others of the use of the circuits. The calling party can help considerably in this regard by planning beforehand what he expects to say and, where necessary, by making notes on the subjects to be discussed. The telephone should not be used for long reports, long orders, or long messages when messenger or teletypewriter service is available. Conversations must be discreet since there is never any certainty of secrecy. Any field wire system may be subject to tapping by the enemy, and the inclusion of radio relay in the wire system will again

vary the degree of security in the system. Messages may be lost through direct tapping, by radio interception, by induction from the lines, or by leaks to the ground. Strong communications discipline must be enforced upon all users of the field wire system.

d. Dealings with operator. The switchboard operator should be treated courteously and no unnecessary conversations should be held with him. *Any complaint regarding the service should be made to the chief operator or to the signal or communication officer.* The operator should not be directed as to how to route a call; nor should the calling party attempt to route his own call by merely asking for a connection to a certain central. The operator is best prepared to put through a call with minimum delay when he is given the complete designation of the party to be called and nothing more.

59. CONFERENCE CALLS. a. Purpose. At certain times, it is desirable for a commander or one of his staff officers to obtain telephone connections with two or more persons at the same time so that he may transmit instructions or information to all parties simultaneously. For this reason, the conference call is used.

b. Procedure. A calling party who wishes to obtain a conference call informs the operator by saying "Conference call" and gives the telephone directory designations of the parties desired, such as Dragoon Six, Domino Six, and Diamond Six. Then he gives

is own directory designation, if necessary. The alling party may instruct the operator that in case he particular person called is not available, other taff officers or their assistants will be satisfactory. After placing a conference call, the calling party nay hang up to await recall by the operator.

60. **PHONETIC ALPHABET. a. Pronunciation of letters.** Certain letters of the alphabet have similar sounds and often are confused in telephone conversations. To avoid this difficulty, the following pronunciation of letters is prescribed for all voice communication, including telephone and radio:

Letter	*Spoken as—*	*Letter*	*Spoken as—*
A	Able	N	Nan
B	Baker	O	Oboe
C	Charlie	P	Peter
D	Dog	Q	Queen
E	Easy	R	Roger
F	Fox	S	Sugar
G	George	T	Tare
H	How	U	Uncle
I	Item	V	Victor
J	Jig	W	William
K	King	X	X-ray
L	Love	Y	Yoke
M	Mike	Z	Zebra

Note. The letters *A*, *I*, *N*, *O*, and *P* are pronounced Affirm, Interrogatory, Negat, Option, and Prep, respectively, when the U. S. General Signal Book is used.

b. Procedure. The words of the phonetic alphabet are used in place of the letters they represent, just as in spelling a word. Expressions such as "A as in

Able" or "A for Able" are not used. For example, in transmitting the words "Barts church," the word "Barts" is likely to be misunderstood. Such words should be spoken and spelled. The transmission is as follows: "Barts, I spell Baker—Able—Roger—Tare—Sugar, Barts church."

c. Coded messages. The phonetic alphabet is used also in the transmission of coded messages by telephone. For example, the code group XISV is transmitted as "X-ray—Item—Sugar—Victor."

61. PRONUNCIATION OF NUMERALS. a. The following pronunciation of numerals is prescribed in telephone transmission:

Numeral	*Spoken as—*	*Numeral*	*Spoken as—*
0	Zero	5	Fi–yiv
1	Wun	6	Six
2	Too	7	Seven
3	Thuh–ree	8	Ate
4	Fo–wer	9	Niner

b. Numbers are transmitted as numerals or digits except in the case of an even hundred or thousand, in which case the word hundred or thousand is used. Example—

Number	*Spoken as—*
44	Fo–wer fo–wer
80	Ate zero
136	Wun thuh–ree six
500	Fi–yiv hun–dred
1478	Wun fo–wer seven ate
7000	Seven thow–zand
16000	Wun six thow–zand

c. When giving a telephone number to a switchboard operator, speak the directory name deliberately and distinctly, pausing between the name and

the first numeral. Pronounce each numeral separately, pausing slightly between numerals. Example—

Directory name and number	*Spoken as—*
Table 44	Ta–ble, fo–wer fo–wer
Turkey 80	Tur–key, ate zero
Track 6100	Track, six wun hun–dred

62. TRAFFIC DIAGRAM. a. General. A traffic diagram is a chart showing the number of telephone or teletypewriter channels existing between the switching centrals of a military wire system. Circuits connecting distant locals also are shown. Only those circuits available for traffic are shown. A single line indicates direct communication. A numeral placed on the line indicates the number of channels available, including simplex, phantom, and carrier circuits. The units served by each switching central or distant local are indicated by the telephone directory name, if used, or by an abbreviated designation. Unit designations are not included in traffic diagrams when signal security is jeopardized.

b. Preparation. A traffic diagram is prepared at each switching central by the wire chief or chief operator, assisted by the operator on duty. In the case of extensive or elaborate systems, traffic diagrams may be prepared for all centrals by the signal officer in charge of the entire system. A traffic diagram of teletypewriter channels is designated as a teletypewriter traffic diagram (fig. 115); one showing telephone channels is designated as a telephone traffic diagram (fig. 116).

c. Purpose. The purpose of the traffic diagram is to indicate to the operator the most direct routing for a call to any other switching central in the system and to show alternate routing in case the direct routing is busy or out of service. For this reason, the diagram often includes connecting systems of higher, lower, and adjacent units. It must be corrected continuously as changes occur and expanded as new information is obtained.

63. TELEPHONE DIRECTORY. a. General. To simplify and expedite the operation of field telephone systems, particularly within divisions, a telephone

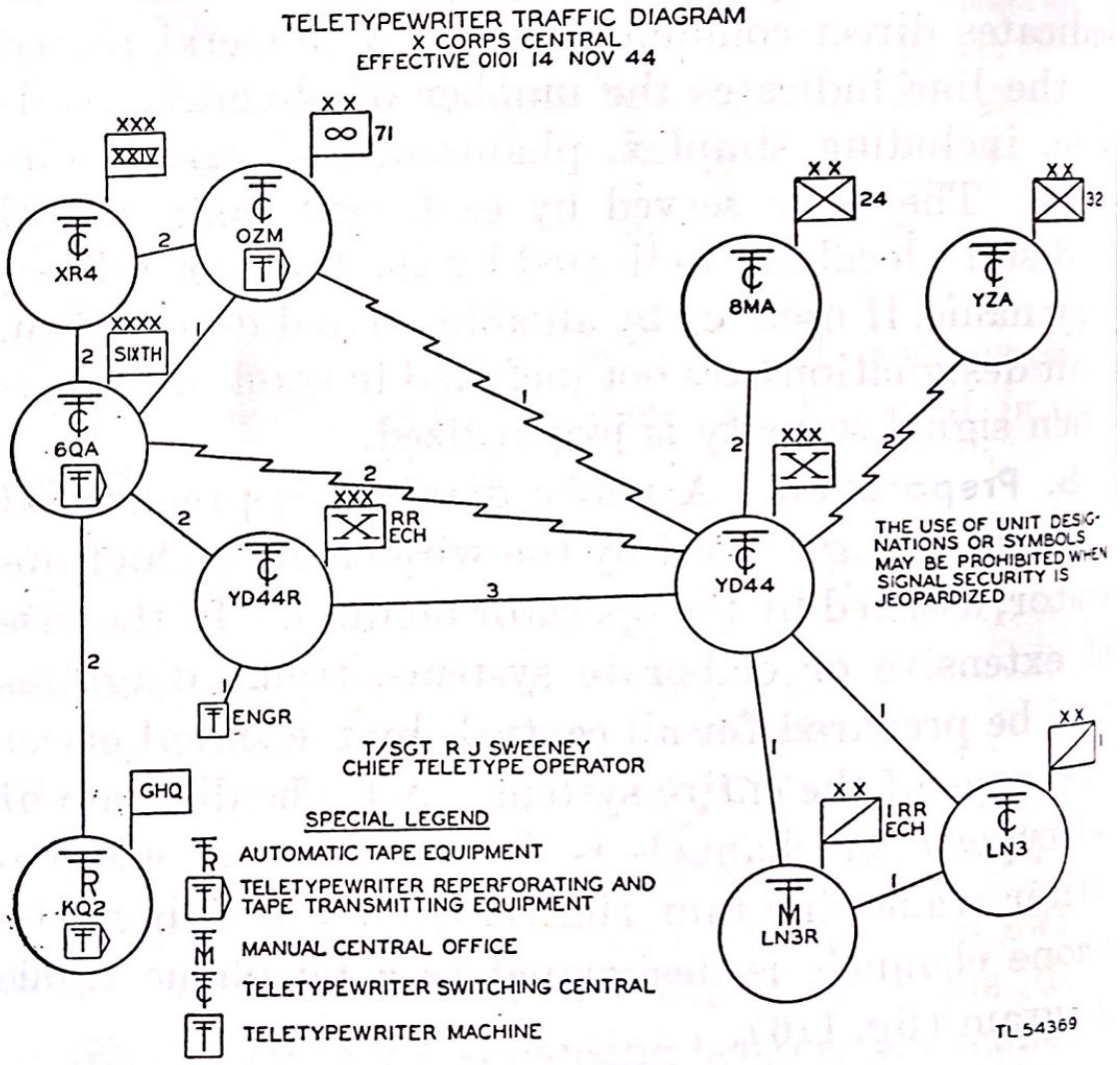


Figure 115. Example of teletypewriter traffic diagram.

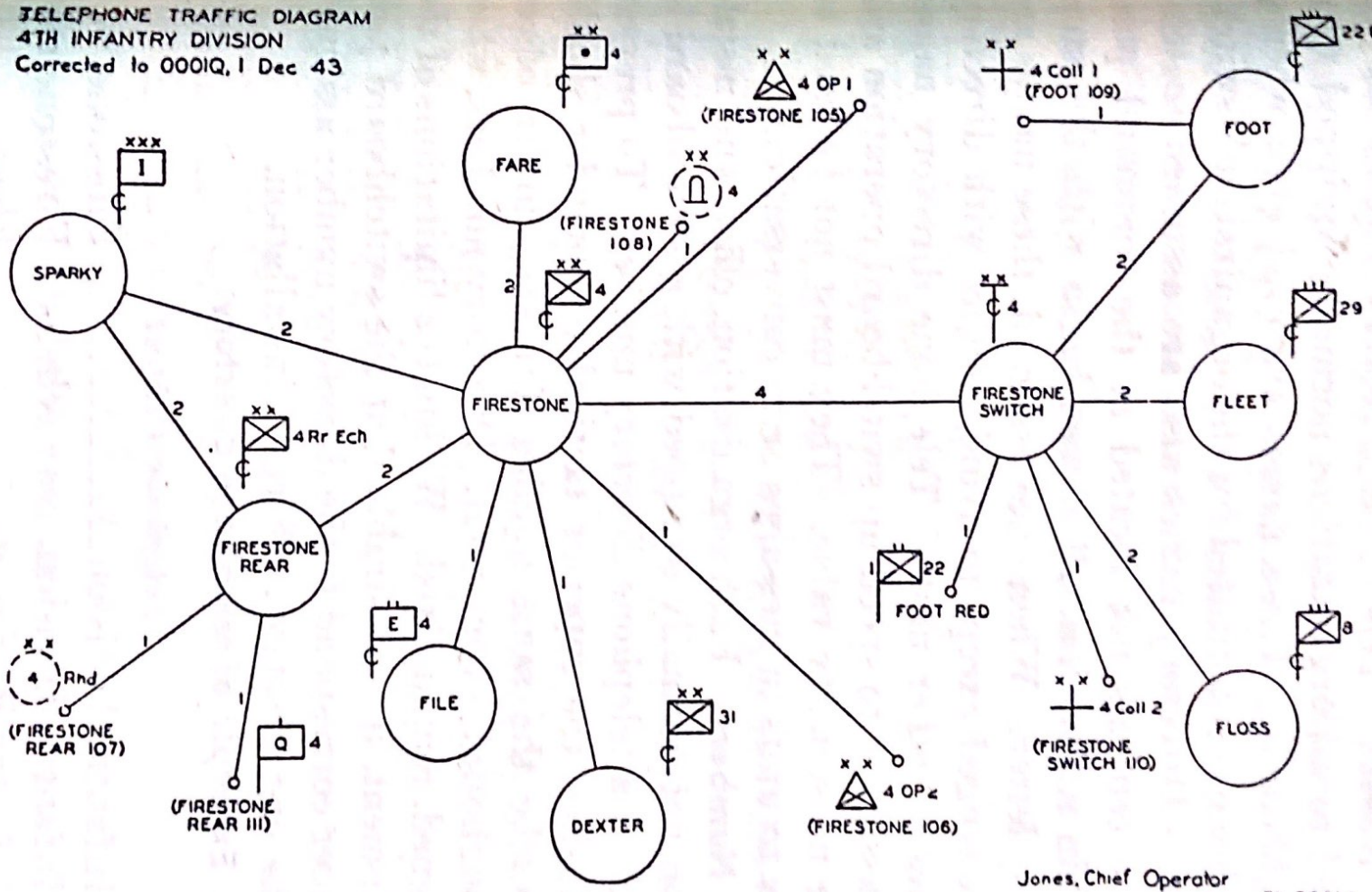


Figure 116. Example of telephone traffic diagram.

directory is used. This directory consists of two parts, directory names and directory numbers; both are issued as one item of SOI.

b. Names. Telephone directory names are assigned to all organizations normally equipped with switchboards. These names are used even when a telephone is substituted for the organization's switchboard. Directory names also are assigned to telephone centrals not located at the command post. Within a division, all names begin with the same initial letter. When once assigned, these names are not changed except to avoid conflict with directory names of other units. Telephone directory names are assigned to speed up switchboard operation and have no security value. They must not be used to refer to units in messages or in conversations.

c. Numbers. Each organization, office, and installation not normally equipped with a switchboard is assigned a telephone directory number. To prevent confusion, the superior tactical commander should prescribe the same number for all similar offices throughout his command. Directory numbers, when assigned, remain fixed. Within the limitations of the equipment, it is desirable that the switchboard jack number correspond to the directory number assigned to the organization, office, or installation.

d. Example of telephone directory.

Telephone Central

4th Infantry Division	Firestone.
4th Infantry Division, rear echelon	Firestone rear.
8th Infantry Regiment	Floss.
22d Infantry Regiment	Foot.
29th Infantry Regiment	Fleet.

4th Infantry Division Artillery_____ Fare.
4th Engineer Battalion_____ File.
31st Infantry Division_____ Dexter.
I Corps_____ Sparky.

Note. RED, WHITE, BLUE, or GREEN added to the telephone directory name of the regiment telephone central indicates the telephone central of the 1st, 2d, 3d, or 4th battalion, respectively.

Telephone directory numbers for officers and offices—

Number	*Title*
1_____	G–1 or S–1.
2_____	G–2 or S–2.
3_____	G–3 or S–3.
4_____	G–4 or S–4.
5_____	Chief of Staff or Executive Officer.
6_____	Commanding Officer.
7_____	Adjutant (Division or higher units).
8_____	Ordnance Officer.
9_____	Inspector.
10_____	Signal or Communication Officer.
11_____	Message Center (incoming).
12_____	Message Center (outgoing).
13_____	Aide-de-camp.
14_____	Air Officer.
15_____	Engineer Officer.
16_____	Surgeon or Medical Officer.
17_____	Judge Advocate.
18_____	Finance Officer.
19_____	Chaplain.
20_____	Postal Officer.
21_____	Quartermaster (not Supply Officer).
22_____	Chief of Artillery or Artillery Officer.

Number	*Title*
23	Chemical or Gas Officer.
24	Liaison Officer.
25	Division Ammunition Office.
26	Pigeon Loft (if applicable).
27	Provost Marshal.
28	Radio Station.
29	Reconnaissance Officer.
30	Telegraph or Teletypewriter Office.
31	Telephone Wire Chief or Trouble Chief.
32	Veterinarian.
33	Public Telephone.
34	Headquarters Commandant.
35	Motor Officer.
36	Antitank Officer.
37	Special Service Officer.

Telephone directory numbers for units:

Number	*Unit*
101	4th Signal Company.
102	4th Medical Battalion.
103	Division Advance Landing Field.
104	Headquarters Company.
105	4th Division Observation Post No. 1.
106	4th Division Observation Post No. 2.
107	4th Division Railhead.
108	4th Division Motor Park.
109	4th Division Collecting Station No. 1.
110	4th Division Collecting Station No. 2
111	4th Quartermaster Company.
112	4th Division Clearing Station.
113	Military Police Platoon.

e. Purposes of directory. Directory names and numbers are not intended for secrecy but rather for purposes of simplicity, accuracy, and speed in the handling of telephone calls. To fulfill its purpose, the telephone directory must be used consistently by all telephone switchboard operators and telephone users. However, operators should be instructed to put through calls regardless of how they may be placed. A copy of the telephone directory should be attached to each field switchboard and telephone in use. Many units have found it convenient to print the directory on a large tag and then attach this tag to the telephone. With this method, one side of the tag has the directory names for each headquarters and the other side has names and numbers for all officers and offices.

f. In larger units. In larger units, such as corps and field armies, use of the telephone directory often becomes impracticable because it is difficult for the switchboard operator and others concerned to memorize the directory names of the many telephone centrals in the system. In such a system, the telephone directory designation of the telephone central may be the most brief understandable abbreviation of the designation of the organization whose headquarters is served by the central. Examples of such designations as spoken are: "First Army"; "Ninth Corps"; or "First Battalion, Seventh" for "First Battalion, Seventh Infantry" when no other organization designated by seven is served by the same system. Examples of a corps telephone directory and an army telephone directory are given in appendix I.

64. RECORDS. At each telephone central, the signal or communication officer prescribes what operational records are to be kept. These records may include a station log and a test-and-trouble record (pars. 65 and 77*d*).

65. STATION LOG. a. The station log is kept by the switchboard operator on duty, under the supervision of the chief operator. A simple form for a station log (fig. 117) contains the following information:

(1) Name of station.

(2) Location, date, and hour at which station opened and closed.

(3) Schedule of operators.

(4) Drop and circuit numbers.

(5) Time at which service opened and closed on each circuit.

(6) Times of interruptions to service.

(7) Remarks (nature of trouble, etc.).

b. At small telephone centrals this form is not required.

66. REPORTS TO MESSAGE CENTER. The operating personnel of a telephone central keep the message center continuously informed of wire communication available to other telephone centrals in the system. Lengthy interruptions or changes also are reported promptly to the message center.

STATION LOG

Station _____

Location	Opened		Closed	
	Date	Hour	Date	Hour

Schedule of operators					
Time		Name	Time		Name
On	Off		On	Off	

Drop No.	Circuit No.	Time service		Interruptions		Remarks
		Opened	Closed	Out	In	

_____
Chief operator

24-FM-20-117

Figure 117. Example of station log for telephone central.

CHAPTER 4

FIELD TELETYPEWRITER INSTALLATION AND OPERATION

67. TELETYPEWRITER CAPABILITIES. The teletypewriter (fig. 118) is a machine designed for interchanging printed messages between two or more stations. Teletypewriters are usually employed between higher headquarters and may be part of the communications system as far down through the chain of command as the regimental headquarters. The reason for this limitation in use is the weight of the equipment necessary to operate the teletypewriter. Under development at present in the Signal Corps laboratories are lightweight teletypewriters that will make the use of teletypewriters more practicable in smaller units.

68. FIELD TELETYPEWRITER SETS. The teletypewriters in common use on field wire systems are Teletypewriter Sets EE–97 and EE–98. Each of these is equipped to function as a complete sending and receiving teletypewriter station, including local and distant line current supply. Teletypewriter Set EE–97 is intended for locations where no power is available or where commercial power may not be available at all times. Teletypewriter Set EE–98 is

intended for locations where 115-volt, a-c or d-c central power source is available at all times. For further detailed description of these sets, see TM 11–354.

Figure 118. Military teletypewriter.

69. TELETYPEWRITER CENTRAL (TTC). a. The usefulness of the teletypewriter is increased tremendously by the use of the teletypewriter central, abbreviated TTC. (The abbreviation for a commercial teletype-

writer exchange, to which military operated teletypewriters may be connected in certain situations, is TWX.) The switchboard for a small teletypewriter switching central is quite similar to a telephone switchboard except that the operator communicates by teletypewriter. A reperforator often may be used to relay messages, or the messages may be relayed by retyping. However, the TTC provides great flexibility in switching between teletypewriter stations, and such connections as two-way station-to-station, conference, and broadcast can be set up quickly. In addition to the provisions for a stand-by and automatic starting and stopping of distant teletypewriters for receiving messages while unattended, the advantages of this system include instantaneous transmission and immediate acknowledgment of receipt typed on the message. The use of the TTC relieves the signal or message center of a large amount of low priority and administrative traffic. This allows the more urgent and important traffic to be concentrated on direct point-to-point circuits for more rapid transmission and better service.

b. Telegraph Central Office Set TC–3 (fig. 119) is an example of a teletypewriter switching central. This set is transportable and can be installed in any headquarters requiring the use of a teletypewriter switching central with a capacity of 10 teletypewriter lines. Each Switchboard BD–100 provides switching and repeating facilities for neutral operation of its 10 teletypewriter lines. Provision is made for quickly connecting any teletypewriter line or trunk to any other line or trunk, or groups of lines

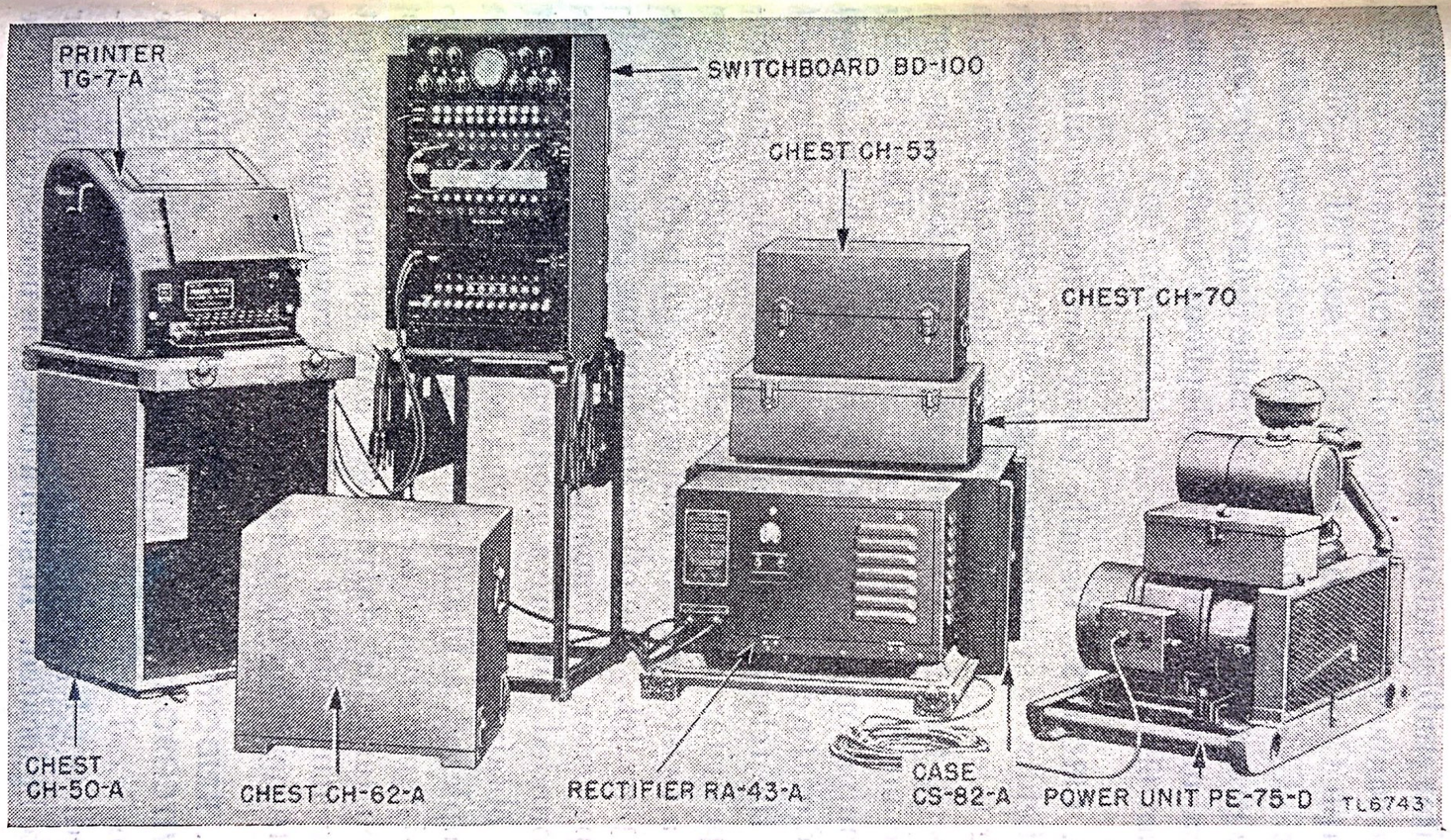


Figure 119. Telegraph Central Office Set TC–3 set up for operation.

or trunks, connected to the switchboard. A teletypewriter enables an operator to answer calls and supervise connections. For complete information on Telegraph Central Office Set TC–3, see TM 11–358.

c. TTC personnel can expedite communication by the preparation and use of traffic diagrams, prepared in a manner similar to telephone traffic diagrams (par. 62).

70. CIRCUITS. Usually teletypewriter circuits used in field wire systems are obtained by simplexing existing telephone circuits. Where the tactical situation is such that hostile interception is unlikely, the earth is commonly used as a return circuit. The TELEG terminal on the repeating coil or switchboard at each end of the circuit is connected to one line binding post of the teletypewriter instrument. This is the teletypewriter leg and may be either a single conductor or a twisted pair of field wires with both conductors in parallel. The other line binding post of the teletypewriter instrument at the terminal station is grounded. Where a good ground connection cannot be obtained and a second telephone circuit can be simplexed, a phantom circuit may be used. A low-resistance ground connection usually is necessary for each terminal station, not only to insure sufficient operating current but also to prevent interference with neighboring teletypewriter circuits.

71. BRIDGING SIMPLEXED CIRCUITS AROUND A SWITCHBOARD. A telephone circuit that is to be simplexed for teletype may pass through an intermediate telephone central at which no teletypewriter is to be located. In such a case, it is necessary to make

the simplex circuit continuous by bridging around the telephone switchboard by means of repeating coils.

72. TELETYPEWRITER WAY STATION. Intermediate stations located between the terminal stations on a teletypewriter circuit are called teletypewriter way stations. The connection may be made at the way station as described in paragraph 71.

73. ESTABLISHING COMMUNICATION. a. On long teletypewriter circuits where good ground connections cannot be obtained, some difficulty may be experienced in establishing communication since the operator at one station may not know when the distant operator is on the line and that the distant operator is attempting to transmit or receive signals. If telephone communication with the distant operator is possible, one operator should call the other by telephone and indicate that he is ready to operate and that he will attempt to establish communication. Whenever operating difficulties arise and it is impossible to contact the distant operator again, the local operator should resort to telephone communication in order to straighten out the difficulties. The unit signal or communication officer should prescribe a definite procedure.

b. When no other means of communication are available, it will be necessary for each operator to adjust his machine for the most sensitive operation, to check all equipment for failures, and to connect his machine to the line and alternately transmit and wait until he succeeds in communicating with the dis-

tant operator. A definite time should be prescribed by the unit signal or communication officer for beginning teletypewriter communication to facilitate establishing the net.

74. TELEGRAPH REPEATER EQUIPMENT. In many situations, teletypewriter communication is limited or unsatisfactory because of the long distance involved and the type of wire facilities available. By the proper use of telegraph repeater equipment, such facilities may be utilized to give satisfactory service.

a. Repeater Set TC–18. This set consists primarily of Repeater TG–30, which is a telegraph terminal repeater used for transmitting to and receiving from another Repeater TG–30 or its equivalent. The repeater is designed for operation on field-wire line, simplexed circuits, or open-wire circuits composited with ground return. The equipment is portable and weighs 130 pounds when inclosed completely in a weatherproof wooden carrying case. For further information on this equipment, see TM 11–2004.

b. Repeater Set TC–19. This set consists primarily of one Repeater TG–31, which is an intermediate d-c telegraph repeater. It is designed for unattended operation at an intermediate location between terminal repeaters, such as Repeater TG–30 or its equivalent. The equipment may be used on teletypewriter circuits operating at speeds up to 66 words per minute over field-wire lines, simplexed, or open-wire lines either composited or simplexed. The complete unit weighs 130 pounds. For further information on the installation, operation, and maintenance of Repeater Set TC–19, see TM 11–2005.

75. OPERATING PROCEDURE AND RECORDS. Station records and operating procedure for military teletypewriters, including relay and switching procedures, will be covered in a JANAP, now in process of preparation. Operating procedure and station records for military manual field telegraph sets are generally the same as for radio, including the use of International Morse characters (see TM 11–454).

CHAPTER 5

MAINTENANCE OF FIELD WIRE INSTALLATIONS

76. GENERAL. Maintenance of field wire installations includes the prevention, detection, and correction of trouble in the system. The maintenance of a wire network during tactical operations is an important task since uninterrupted telephone service is essential to a successful air or ground operation. Maintenance problems will develop that can be overcome only by careful planning and constant effort. Careful selection of initial wire routes and standard installation will assist greatly in overcoming these difficulties and reducing the maintenance problem. Personnel assigned to maintenance and patrol activities should be selected carefully and should be the best qualified available for this work. See TM 11–757, Principles of Line Fault Location, which, when published, will be listed in FM 21–6.

a. Preventive measures. The following actions will assist in keeping troubles to a minimum:

(1) Conference between signal and communication officers, with reference to the location of wire lines. Wire lines should be routed and switching centrals and stations located to avoid hostile artillery fire, land mines, and aerial bombardment as far as practicable. Care should be taken at all times to protect lines and equipment from accidental injury by friendly troops and traffic.

(2) Continuous patroling of the wire lines by two- or three-man teams to make minor repairs or rearrangements of wire conditions which ultimately might cause trouble.

(3) Training of all operating and using personnel in the proper use and care of wire equipment.

(4) Careful handling of wire equipment and its protection from moisture while it is in storage, in transit, and after it is installed.

b. Trouble on wire lines. Trouble that occurs in field wire systems is of two classes: that which causes an *interruption to* service and that which is located and cleared *before* an interruption to service occurs. Most trouble may be kept in the latter class by an alert maintenance crew making proper routine tests. When trouble occurs, it should be located and cleared as soon as possible by methodical locating procedure, and proper repair or replacement of equipment should be made. All trouble, whether detected by operating and maintenance personnel or reported by users, is recorded and followed up until cleared. Clearing of trouble on wire lines is facilitated by the establishment of test stations at important junctions and at points near where trouble is anticipated.

77. ROUTINE TESTS. a. Frequency. The frequency with which routine tests of circuits and equipment should be made varies and is determined by the nature and importance of the circuits, type of equipment and its manner of installation, amount of traffic handled, and amount of trouble experienced. The frequency of these tests is prescribed by the signal or communication officer. All local and trunk circuits

and their operating equipment are included in these tests. In general, circuits that are kept busy do not require as frequent routine tests as those that are seldom used. Communication is never interrupted to make a routine test, since a busy circuit obviously indicates that it is not in trouble. Circuits that have been busy and suddenly become idle are checked by the switchboard operator at the first opportunity.

b. Trunk circuits. Ordinarily, routine tests of trunk circuits are made by the wire chief, although they may be made by the switchboard operator if making the tests does not interfere with the prompt handling of traffic. The tests include checks to see that each switchboard can be signaled from the command post switchboard and that the voice transmission in each direction over the circuits is clear and satisfactory.

c. Local circuits. Ordinarily the routine tests of the local circuits are made by sending a maintenance man to the local telephone to test the circuit back to the wire chief or switchboard operator. The test includes checking to see whether the switchboard can be signaled from the telephone, and vice versa, and whether satisfactory voice transmission in both directions exists over the circuit. Where it is impracticable to send a man to the local telephone, as in the case of a long circuit, the user is called and requested to make the test. Ordinarily, however, users are not requested to make routine tests of local circuits.

d. Keeping records. A record of installation time, tests made, and troubles found or reported on trunk circuits is kept by the wire chief at each telephone

central on a form like the one illustrated in figure 120. Such a record should include the following information:

(1) Directory name of station.

(2) Location, date, and hour of opening and closing.

(3) Schedule of assistant wire chiefs.

(4) Drop and circuit numbers.

(5) Time at which lines were connected to switchboard.

(6) Time at which service was opened on each line.

(7) Time of interruptions to service, with notation of personnel clearing trouble.

(8) Time service terminated on particular line.

(9) Remarks (nature of trouble, etc.).

78. CIRCUIT TROUBLES. a. Character. Trouble on a field wire circuit is indicated when it is impossible to signal or to be signaled, when it is impossible to hear or to be heard, when the transmission is weak, or when noise on the circuit or cross talk from other circuits interferes with conversation. A knowledge of the various troubles and the manner in which they affect transmission will aid in localizing troubles when they occur.

b. Cause. Trouble may occur either in the line wire itself or in the operating equipment attached to it. Usually the trouble is the result of an *open*, a *short*, a *ground*, or a *cross*, or any combination of these faults at one or more points in the circuit.

(1) The open circuit, or *open*, is a break or cut in the conductor either on one or both sides of the circuit.

INSTALLATION AND TROUBLE RECORD

Station_____

Location	Opened		Closed	
	Date	Hour	Date	Hour

Schedule of ass't wire chiefs

Time		Name	Time		Name
On	Off		On	Off	

Circuit No.	Drop No.	Time line connected	Time service opened	Interruptions			Time service closed	Remarks, nature of trouble (etc.)
				Time out	Time in	Cld. by		

_____
Wire chief

24-FM-20-120

Figure 120. Example of installation and trouble record.

(2) The *short circuit*, or *short*, is caused by electrical contact between the two conductors of a circuit. It may be the result of bruised or stripped insulation which either allows the bare wires to touch each other or allows electricity to be conducted from one to the other when the conductor is wet.

(3) The *grounded circuit*, or *ground*, occurs when there is an electrical path to earth from one or both conductors of the circuit. It also may be the result of bruised or stripped insulation or a poorly taped splice if the splice is lying on the ground or in water. The effects of grounds will be most pronounced in wet or damp weather.

(4) The *crossed circuit*, or *cross*, is caused by electrical contact between conductors of two adjacent circuits and is in reality a short circuit between a conductor of one circuit and a conductor of another.

c. Effects on telephone transmission. (1) An *open* interrupts telephone communication completely. However, a partial open, such as one which results from a poorly made splice or a loose contact, introduces a high resistance in the circuit. It may not destroy communication completely, but transmission becomes weak and often noisy.

(2) A low-resistance *short* interrupts telephone communication completely. A partial (or high-resistance) short results in weakened transmission and may affect or prevent ringing.

(3) A *ground* on both sides of a circuit produces an effect similar to that of a short. Usually a ground on only one side of a circuit does not interrupt telephone communication but may produce a hum or noise in the circuit.

(4) A *cross* is likely to result in a cross talk or interference between the two circuits involved and may or may not be sufficient to render the separate conversations unintelligible.

d. Effects on simplex teletypewriter operation. A simplex teletypewriter channel may continue to operate under certain trouble conditions, even though the physical circuit on which it is superimposed is inoperative for telephone communication. This emphasizes again the value of the simplex teletypewriter channels.

79. EQUIPMENT FOR TESTING. The nature of trouble on a field wire circuit or in operating equipment can be determined with any of the following equipment in the manner described below.

a. Field telephone. Any field telephone may be used for testing line or equipment circuits. For convenience in making tests, the telephone is equipped with a pair of test leads made of lamp cord, field wire, or other flexible twisted-pair wire about 3 feet long. A test clip is soldered to one end of each conductor and, if stranded wire is used, the other end which is to be connected to the line terminal of the telephone is soldered lightly to hold the strands together and to prevent accidental short circuits at the telephone terminals. The following tests may be made:

(1) *Test for an open.* Connect the ends of the circuit to the line terminals of the test telephone and turn the generator crank rapidly. If the generator crank turns freely without any drag on it, the circuit is probably open.

(2) *Test for a short.* If the generator turns quite

hard, as if a drag had been placed on it, with the telephone connected as in the preceding test, the circuit is probably short-circuited or grounded on both sides.

(3) *Test for a ground.* Connect one side of the circuit to one line terminal of the telephone and connect the other line terminal of the telephone to ground. If there is a ground on that side of the circuit, the generator will turn hard as in the case of a short. Test the other side of the circuit in a similar manner.

(4) *Test for a cross.* Connect one side of the circuit to one line terminal of the telephone and connect the other line terminal of the telephone to the conductor with which the circuit may be crossed. If there is a cross, the generator will turn hard, as in the case of a short. Test each side of the circuit in a similar manner with any conductor with which it might be crossed.

b. Receiver and battery. A telephone receiver connected in series with a battery and fitted with leads may be used for testing (fig. 121). The terminals of the test leads may be either test clips or short lengths of stiff copper wire. The apparatus is suitable for making the following tests:

(1) *Test for complete circuit.* Connect the test leads to the ends of the circuit to be tested. If the circuit is complete, a distinct click will be heard in the receiver.

(2) *Test for an open.* Connect the test leads to the ends of the circuit to be tested. Failure to obtain the distinct click on successive attempts to complete the circuit indicates an open circuit.

(3) *Test for a short.* Connect the test leads to the ends of the circuit to be tested. Open the other end of the circuit. If a short exists, the result will be the same as for a complete circuit; that is, a distinct click will be heard in the receiver.

(4) *Test for a ground.* Connect one test lead to the circuit to be tested. Connect the other test lead to ground. If the circuit is grounded, the results will be the same as for a complete circuit.

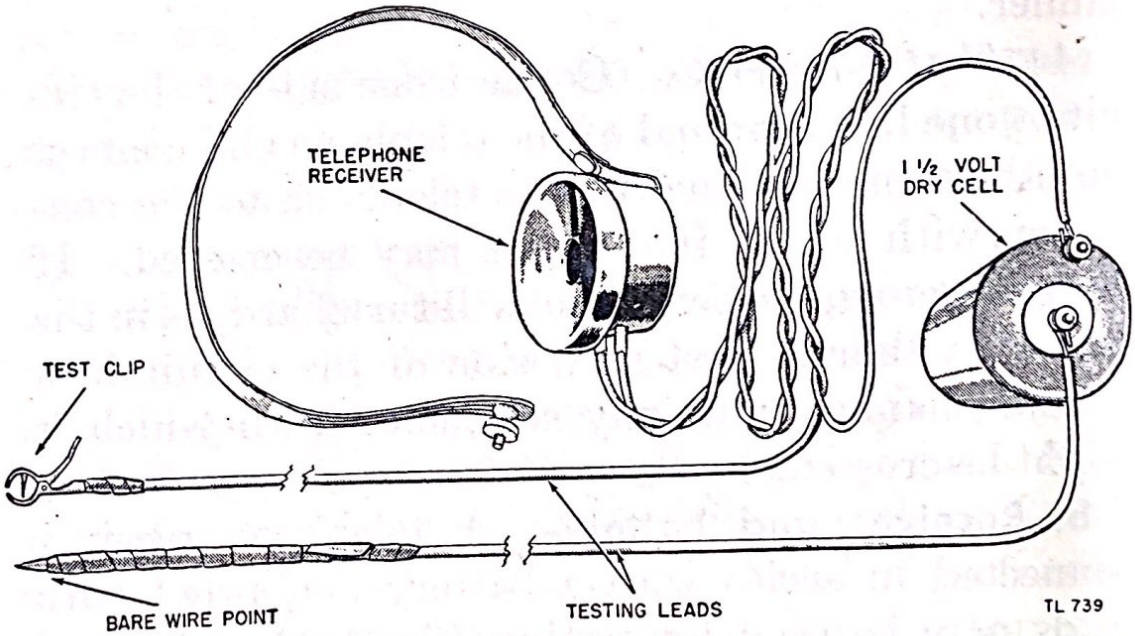


Figure 121. Receiver and battery connected for use in testing circuits.

(5) *Test for a cross.* Connect one test lead to the circuit to be tested. Connect the other test lead to the circuit with which the circuit to be tested is believed to be crossed. If one is crossed with the other, the result will be the same as for a complete circuit.

Note. Considerable care must be taken when making this test to distinguish between the receiver clicks of a complete circuit and an open circuit. On a succession of tests if all clicks are of the same intensity, the circuit is complete. On

an open circuit the first click, caused by the capacity effect, may be rather loud; however, successive tests will produce clicks of greatly reduced intensity, indicating that the circuit is open.

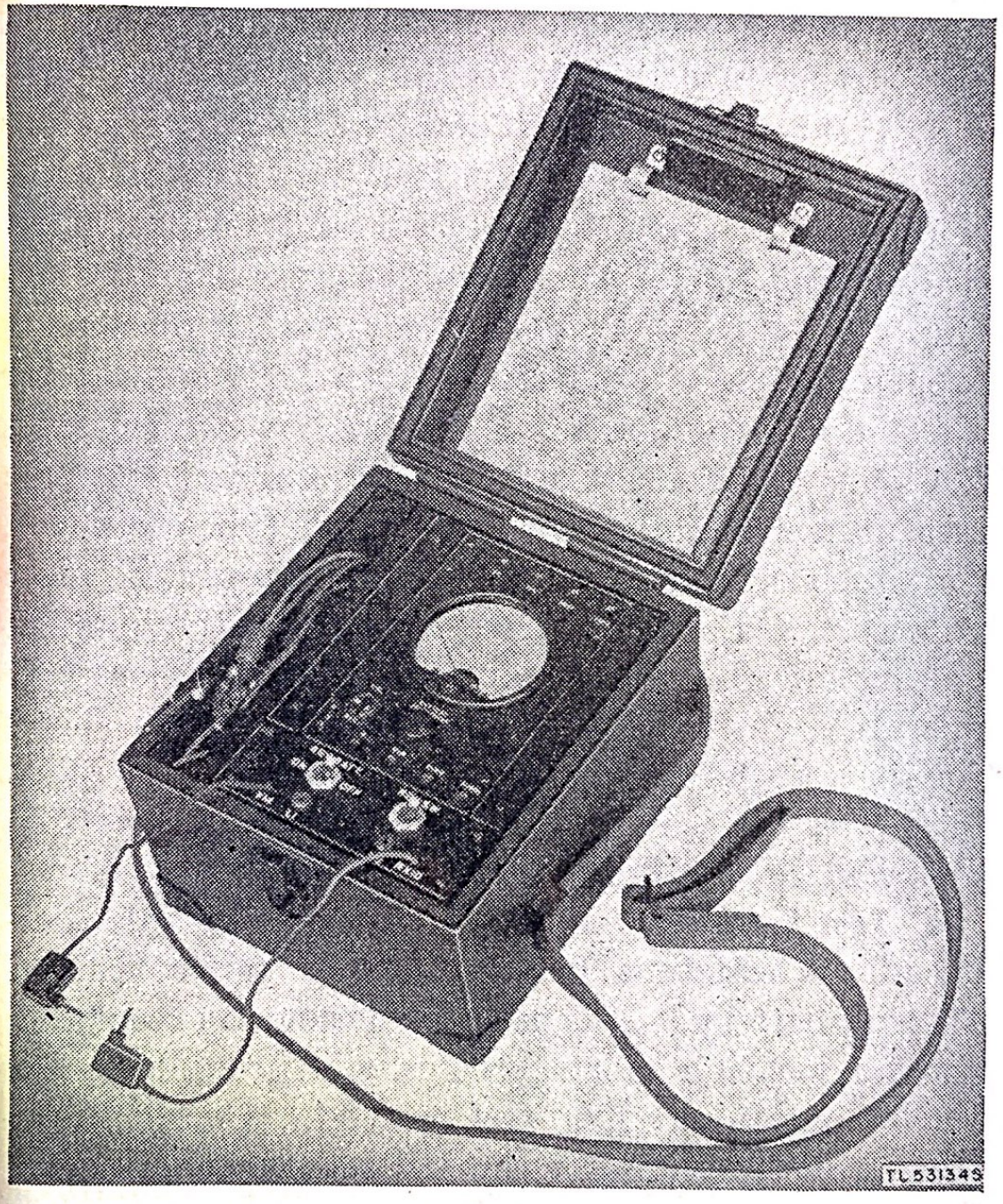


Figure 122. Test Set TS–26/TSM, over-all view.

c. Test Set TS–26/TSM. This test set is a voltohmmeter equipped with test leads, a 315,000-ohm resistor, a reversing switch, and a 45-volt battery (fig. 122). The test set can be used to measure insulation

and conductor resistance and to detect ground crosses, shorts, and opens. This testing equipment is very effective for trouble locations on short-cable circuits and may be improvised from any available voltohmmeter when an issued set is not available. For further information see TM 11-2017.

d. **Test Set TS-27 TSW (Combination-bridge).** This test set is a portable, fault locating set with a slide-wire bridge for measuring conductor and insulation resistance and for locating grounds, crosses, and shorts (fig. 128). An ac bridge is provided for measuring capacitance and for locating opens. Potential for the bridge measurements is supplied by two batteries BA-30. A 20-cycle alternating current for ac measurement is supplied by a vacuum tube oscillator for which the same batteries BA-30 supply the plate voltage. A battery BA-15-A supplies the filament voltage for the vacuum tube oscillator. Complete operating instructions and calibration-curve sheets for the various types of wire and cable are included in the test set cover. For further information on Test Set TS-27/TSW refer to TM 11-2017.

e. **Test Set I-49.** This test set is a portable dial-decade Wheatstone bridge using a self-contained 4½-volt battery. It is used for measuring resistance and for locating shorts, crosses, and grounds by the Varley or Murray loop-test method. Complete operating instructions for the test set are contained in the cover.

f. **Test boards.** Test boards may be improvised from any of the above-mentioned test equipment and a small switchboard, such as Switchboard BD-71, BD-72, or SB-4/PT. The arrangement of the equip-

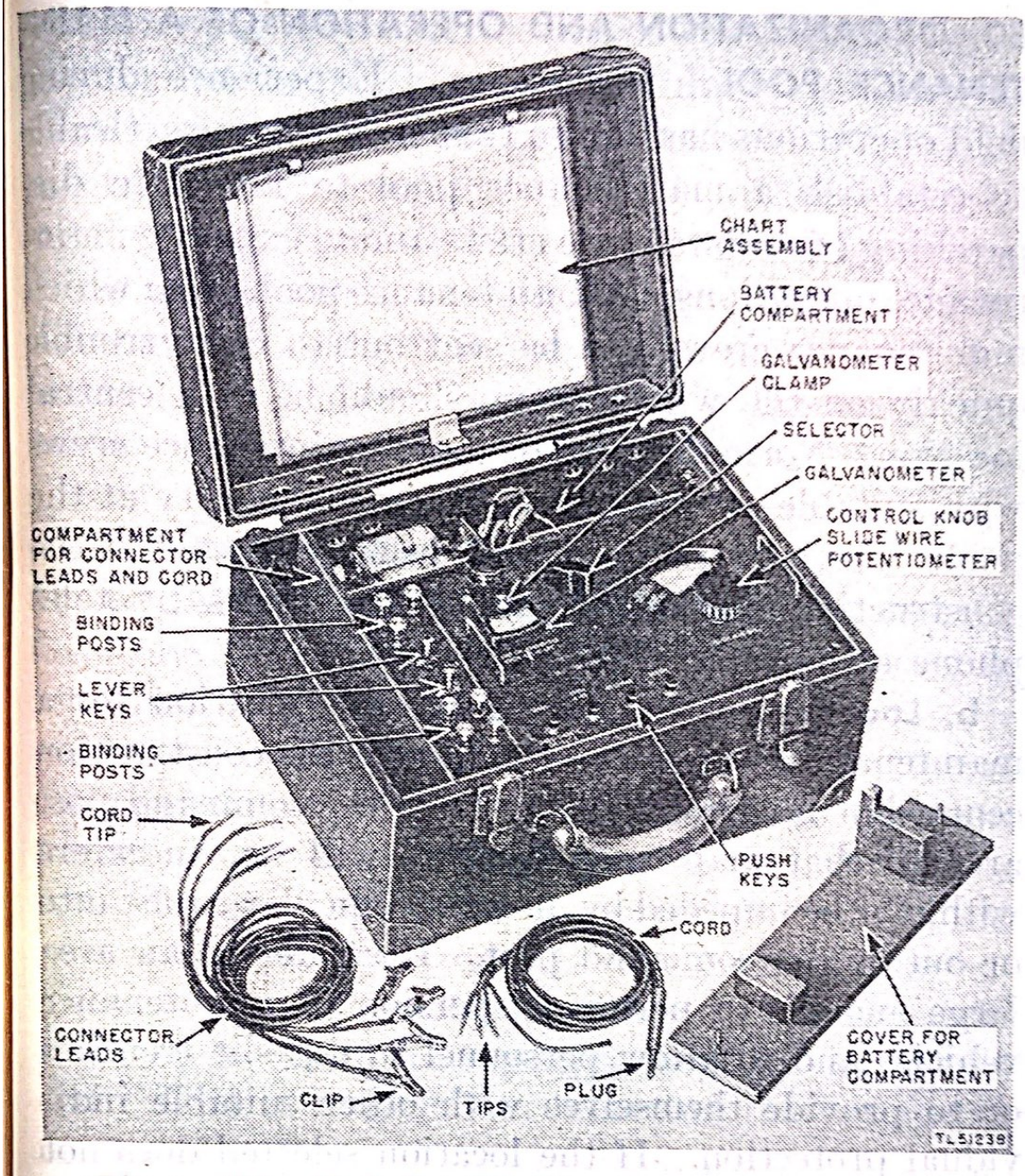


Figure 123. Test Set TS–27/TSM with cover raised.

ment can be similar to that described for the construction center (par. 26) or it can be made more elaborate, depending on the needs of the unit and the equipment available. The importance of the use of a well-planned construction center cannot be overemphasized. The performance of the telephone operation center will depend to a great degree on the efficient operation of the construction center.

80. ORGANIZATION AND OPERATION OF A MAINTENANCE POOL. a. Purpose. Experience during field operations has shown that it is often practicable to establish a maintenance pool to facilitate dispatching of maintenance crews and to expedite maintenance operations. A maintenance pool, from which maintenance crews can be sent out to clear trouble quickly on the wire system, should be at a central location. Normally, two or more maintenance crews with suitable equipment are assigned to duty at the pool. The construction chief, usually located at the construction center, dispatches the crews by telephone as they are needed (**c** below).

b. Location. Normally, a suitable location for a maintenance pool can be found near the construction center but far enough away from the command post area so that maintenance crews will not interfere with, nor be impeded by, normal vehicular traffic into or out of the command post. It should be an area large enough to permit dispersion of maintenance vehicles and to allow personnel to dig slit trenches or to provide themselves with other suitable individual protection. If the location selected does not provide adequate concealment from observation for vehicles and personnel, camouflage should be used.

c. Operations. At all times during operations one maintenance crew must be on the alert and ready to move out to locate and clear trouble on the wire system or to perform any other assignment within its capabilities. Upon being dispatched, this crew must alert the next crew on call in order to provide continuous and prompt availability of maintenance personnel. Crews may be dispatched in a systematic

rotation or in any other sequence that assures equal distribution of work. In scheduling the duty of maintenance crews, make provision for regular meals and rest periods, so far as possible without decreasing the efficiency of operations. Construction crews, and any other personnel temporarily assigned to wire maintenance duty, may be stationed at and dispatched from the maintenance pool in the same manner as the regular maintenance crews. Wherever possible, trouble on a line should be cleared by the team that constructed the line.

81. LOCATING AND CLEARING TROUBLE. a. General localizing of trouble. When trouble is detected or reported on a circuit, the first step is to determine whether the trouble is in the line wire itself or in the operating equipment. If tests made from the terminal equipment toward the switchboard show no trouble in the operating equipment when the line wire is cleared from terminal equipment at the terminal strip, the trouble is either in the line wire itself or in the operating equipment at the distant end. This is verified by connecting the test equipment to the line and testing toward the distant end of the circuit. Trouble on a trunk circuit may be localized still further, provided an additional good circuit is available, by requesting the wire chief at the distant end to clear the faulty circuit for the operating equipment at that end. Then the circuit is tested again for an open with the distant ends of the circuit open and for a complete circuit with the distant ends of the circuit connected together. If the trouble is in the line wire itself, it will be revealed during the tests. If the tests show the line

wire to be good, the trouble is in the operating equipment at the distant end, and the wire chief there is notified and requested to clear the trouble and reconnect the circuits.

Caution: Always listen in on a circuit to determine whether or not it is in use before opening the line for tests. Never open up a circuit on which someone is talking.

b. Short local circuit trouble. If, upon making the first test (**a** above) at the terminal strips the trouble is found to be toward the user's telephone, the circuit is reconnected and a trouble man is dispatched to the user's instrument with a serviceable telephone. On his way, he inspects the circuit for visible sources of trouble and repairs any trouble that he finds. He then makes a ringing and talking test with the user's telephone. If he cannot signal the operator with it, he replaces the local instrument with his own instrument and repeats the test. If he can now signal and converse with the operator, the trouble is in the local telephone, which he either repairs or replaces. If he cannot signal the operator, the trouble is probably in the local line circuit. He first tests for a short and an open circuit; then he tests for a grounded circuit and, if applicable, for a cross with another circuit. If trouble is located in the line wire, he works back toward the switching central, making a careful inspection on the line wire and paying particular attention to splices and other possible defective points over its entire length. If he locates the fault, he repairs it and notifies the user that the service is again available. If careful inspection does not disclose the fault, time may be saved by running a new circuit.

This circuit is connected into the switchboard, the local telephone is connected at the end of the circuit, and the new installation is tested.

c. Trunk circuit or long local circuit trouble. (1) If the tests described in *a* above determine that the trouble is in the line wire of a trunk circuit or in a long local circuit, the wire chief determines, as accurately as his instruments permit, the nature and approximate location of the trouble. This facilitates the testing and shortens the time required to locate and clear the trouble.

(2) The circuit in question is connected to a test telephone at the switchboard terminal strip, or it is left connected into the switchboard if there is not sufficient maintenance personnel available to man the test telephone. A lineman is sent out on the line with a test telephone to test methodically from various points back to the man at the switchboard terminal strip or to the switchboard operator. The lineman should take with him a telephone equipped with test clips, Tool Equipment TE–33 (knife and pliers kit), friction tape, rubber tape, seizing wire, tags, Lineman's Equipment TE–21 (if needed), and a 50-foot coil of the same type wire as used in the faulty line. Starting from the switchboard terminal strip, the lineman carefully examines the circuit as he proceeds, paying particular attention to the insulation, splices, underground and overhead crossings, ties at long spans, and places where the wire has been passed over or pulled out of place by vehicular traffic. Ties on swaying trees and at road crossings must be checked. If engineer or other troops are working in the vicinity of the right-of-way and line trouble

is experienced, check at the location of the working parties. Fouled insulation, poor splices, and other evidences of possible trouble are repaired and the circuit is tested in order to determine whether the trouble has been cleared. If no obvious troubles are found, the lineman bridges his telephone across the circuit at intervals and tests.

Caution: Never use test clips with steel points to puncture the insulation on Wire W–143, because the steel points will cause either one or both sides of the wire to be grounded with the stabilizing shield around each wire.

(3) In testing the defective circuit for an open, the lineman connects the test telephone across the circuit without opening the circuit. If testing for a ground or a short, the lineman opens the circuit and then tests in both directions. Before opening the circuit, however, he connects his telephone to the line with the test clips and attempts to communicate in either direction, since the trouble may have been cleared in the meantime by other personnel. In case it is necessary to open the circuit, the lineman opens it at a splice or at a test point if practicable. After making each test, he reconditions the circuit by taping wherever a test clip had been connected, or by splicing and taping wherever the wire was cut.

(4) Upon making each test, the lineman can determine whether the circuit is good between his location and the telephone central by trying to ring and talk to the man at the switchboard terminal strip or the operator. If a test toward his own telephone central is successful, the fault still lies beyond in the direction of the distant telephone central, and

the lineman continues to work in that direction. If he is unsuccessful in reaching his own telephone central during any test, he has passed the fault and therefore works back over the circuit, cutting in half the distance between successive tests. By following this procedure, he can locate the fault between two points a short distance apart. Then he inspects this section of the line carefully until he locates the actual fault. The fault is repaired as required: by splicing, by cutting out and replacing the faulty section, or by taping.

(5) A defective circuit may have more than one fault. It is therefore essential that the lineman, after clearing each case of trouble, test the circuit in both directions to determine whether it is in order. If trouble still exists, he continues his inspection until all trouble has been located and cleared.

(6) Considerable time is consumed in splicing a circuit after each test for a short or ground, and this delays seriously the ultimate locating of a fault if such tests are made at too frequent intervals along the circuit when first starting. A visual inspection of the circuit by the lineman as he progresses along the route frequently will disclose the fault. A knowledge of the geographic location of a circuit will aid the wire chief in predicting the probable location of a fault, after having determined its nature. The wire chief may direct the lineman to make tests from the vicinity of such points, or he may specify the approximate interval for making tests. A good rule is: After passing any portion of the circuit that cannot be inspected visually, connect the telephone and test.

d. Directed and undirected sectionalizing and hunting. The procedure described in **c** above is *undirected sectionalizing and hunting*. *Directed sectionalizing* is similar to undirected, except that whenever a test is made, it is possible to determine not only the direction of the trouble from the testing point but also the approximate distance from the point. An example of directed sectionalizing would be the location of a ground by means of the combination-bridge Test Set TS–27/TSM. Directed hunting is a method of finding a fault, by means of electrical-exploring apparatus, that has been sectionalized between two points. For example, in locating a short circuit between two points, an oscillator may be connected at one of the points so as to impress a tone on the line. Then a lineman walks along the line with a pick-up coil, amplifier, and telephone receiver and listens to determine the point at which the tone disappears. He is then in the vicinity of the trouble. The directed method of sectionalizing saves considerable time by immediately eliminating from suspicion a large portion of the line. In the majority of cases, one step, or at the most two steps, of directed sectionalizing will narrow down the location of the trouble so that the actual location can be determined readily with a minimum of hunting.

e. Removing trouble. When a circuit is repaired in the field, speed is restoring service comes first and proper technique in splicing comes next. When a break in a line is repaired, communication is restored immediately by completing the square knot in each wire. Then, while the bare wires are kept sepa-

rated to prevent a short circuit, the splice is completed and taped. A valuable addition to a lineman's equipment consists of two short pieces of wire, about 3 feet long, with test clips on each end. These jumper wires are used to bridge a break during the construction of a splice, thus keeping the circuit in operation. When using jumper wires, care is taken that a short circuit is not caused while splicing. In locating trouble, linemen are sent out from each end of the circuit and work toward each other. The wire chiefs at both ends are responsible that the trouble is cleared, regardless of where the trouble was first discovered.

f. Trouble in local operating equipment. If the trouble originally was found to be toward the operating equipment at the central, it may be localized by opening the circuit at various places, such as at line terminals, fuses, protectors, etc., and by repeating the tests. Terminal strips and connections are inspected carefully for shorts, opens, and crosses. If the trouble is in the equipment itself, it can be located by a rigid system of testing, such as prescribed for that specific piece of equipment or in the technical manuals relating to the equipment. In the case of a faulty unit in a switchboard, use of this unit should be discontinued and the circuit transferred to a spare unit until repair or replacement can be made.

82. OPERATION OF TEST STATIONS. a. Personnel. The personnel at a test station may consist of one or more linemen, as the situation requires. When the talking range will not be affected adversely, a test telephone may be kept bridged across a circuit; usu-

ally the lowest numbered telephone circuit passing through the test station or a special circuit ending at the test station may be reserved temorarily for test purposes. The personnel on duty at the test station are instructed to answer prearranged signal only; for example, three short rings. When answering this prearranged signal, the test station personnel state the name of the test station. The test station personnel then are instructed in patching, testing, or repairing circuits, as the situation requires.

b. Testing circuits. Test station personnel should keep informed constantly as to the serviceability of the circuit across which the test telephone is bridged by listening for the normal signaling and conversation that passes over the circuit. If the circuit becomes idle, it is tested promptly and frequently thereafter. If these tests show the circuit to be in trouble, the test telephone is bridged across another circuit and a report is made to the switchboard operator or to the wire chief.

c. Correcting troubles. The procedure of locating and clearing trouble on defective circuits that pass through test stations manned by linemen is facilitated by the fact that the wire chief can call each successive test station and quickly determine the faulty section. Then the nearest test station can be directed to dispatch a lineman to locate and clear the trouble. In the meantime, serviceable sections may be patched as described in paragraph 83. A copy of the circuit diagram and line route map, indicating all circuits passing through or terminating, is kept posted at each test station.

83. PATCHING CIRCUITS AT TEST STATIONS. a. Purpose. The patching of circuits at test stations frequently results in maintaining communication between centrals during the locating and clearing of trouble on the defective sections of the original circuits. If this patching were not done, communication would be interrupted until the trouble had been cleared. The example in **b** below illustrates how the patching may be used to advantage.

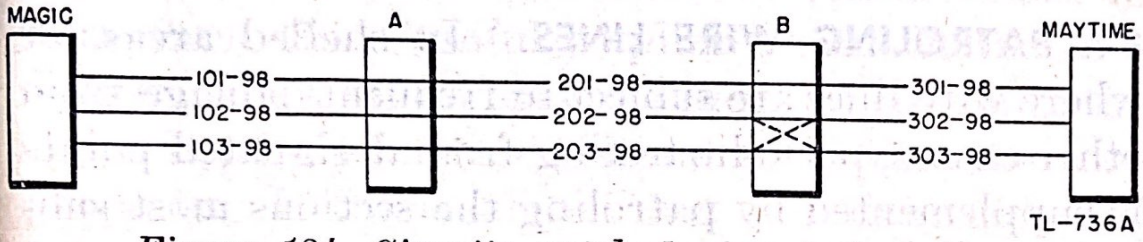


Figure 124. Circuits patched at a test station.

b. Patching procedure. Assume that two telephone centrals are connected by three circuits, all of which pass through two test stations, as shown in figure 124. The telephone switchboard operator at MAGIC reports to the MAGIC wire chief that circuits 102–98 and 103–98 to MAYTIME are out of order. The wire chief at MAGIC tests these two circuits. With the aid of a serviceable circuit to his test station, he finds that the trouble on the 102–98 circuit is located in section 202–98 between test stations A and B, and the trouble on the 103–98 circuit lies in section 303–98 between test station B and MAYTIME. He then instructs the lineman at B to connect circuit 203–98 to circuit 302–98, and circuit 202–98 to circuit 303–98. This immediately gives one serviceable built-up circuit from MAGIC to MAYTIME, in addition to the (101–98)–(201–98)–(301–98) circuit. The MAGIC

wire chief informs the lineman at A and the MAYTIME wire chief of the changes made at B, so that all circuit diagrams can be changed accordingly. When the interrupted circuits have been repaired, the MAGIC wire chief is notified. Upon instruction from him, the original connections are restored during an interval between busy periods, and the lineman at A and the MAYTIME wire chief are notified that this has been done.

84. PATROLING WIRE LINES. In shelled areas, or where wire lines are subject to frequent damage from other causes, periodic testing from designated points is supplemented by patroling the sections most subject to damage. Whenever possible, the personnel that have constructed a given section are assigned also the mission of patroling that section. Wire patrols, to be effective, must inspect carefully every foot of the wire in the sections they cover. A wire pike or an improvised wire guide, made by fastening a bridle ring to a hand grip, may be used. Wire patrols repair trouble whenever and wherever found. They replace doubtful splices or sections of the line, tape any insulation abrasions, and generally improve the line construction.

85. TESTING FIELD WIRE ON REELS. All insulated wire is reconditioned carefully after use, as follows:

a. Mount an empty reel and the reel containing the wire to be tested, so that the wire may be wound on the empty reel from the full reel.

b. Pass the end of the wire through the holes provided near the drum of the empty reel and secure it

so that the end will protrude from the side of the reel. This end must be free for use in future testing.

c. Station an experienced man between the reels to examine the wire carefully as it is wound slowly onto the empty reel. Cover each abrasion or break in the insulation with tape. If only the braid is broken, apply two layers of friction tape. If the bare wire is exposed, remove the ragged portions of the insulation and cover the wire with two layers of rubber tape and two layers of friction tape, as described in paragraph 16. Carefully splice breaks in the conductor. Untape and examine each old splice; if the splice is poorly made, cut it out and splice the wire properly. If the insulation has been damaged over a long section of the wire, or if there are several splices very close together, cut out the faulty section.

d. After each splice, and also when all the wire of a reel is repaired completely, test the wire on the reel being filled for an open circuit or a short circuit between two wires. These tests may be made with any of the equipment described in paragraph 79.

86. TRANSPORTATION OF WIRE EQUIPMENT IN THE FIELD. a. Operating equipment. Operating equipment is comparatively delicate, and its serviceability is governed to a great extent by the care taken in packing it for transport. Operating equipment is packed and loaded in such a way as to protect it from—

(1) Dust and dirt.
(2) Weather.
(3) Shocks of the road.

(4) Damage from other articles loaded in the same vehicle.

b. Telephones. Field telephones are carried in pack chests whenever these chests are provided. Handsets and cords are placed neatly in their proper compartments. Batteries are removed. Removable generator cranks are placed inside the cases, and the cases are closed and strapped.

c. Switchboards. Monocord switchboards, with cable and switchboard terminal strip attached, are packed in a pack chest separate from telephones. Before being placed in the chest, the switchboards are placed in their carrying cases with shutters locked and cable neatly coiled.

d. Repeating coils, loading coils, terminal strips, spare batteries, and spare parts. These are carried in the chests provided, packed carefully to prevent damage.

e. Wire. The principal precaution necessary in transporting wire is that the metal drums or commercial spools should not be dropped from vehicles or handled in such a manner as to damage or bend them and make their refilling and use difficult. The new wire dispenser as described in paragraph 23 will withstand considerable rough handling. Wire should be protected from being crushed by other objects transported with the reels.

APPENDIX

EXAMPLES OF A TELEPHONE DIRECTORY FOR CORPS AND ARMY

1. TELEPHONE DIRECTORY. In both examples the base number is the same as the telephone directory number in paragraph 63. In order to designate substations for the several sections of a headquarters, the hundreds digits are used.

Administrative or personnel subsections	100.
Intelligence or investigating subsections	200.
Plans and training subsections	300.
Supply subsection	400.
Executive officer	500.
Private phones	600.
Miscellaneous	700 and above.

2. USE. In order to use either of these directories it is necessary to renumber the switchboard jacks. Strips of paper can be pasted above the jacks with the new numbers typed or printed thereon. The 101 and 201, etc. numbers start at the upper left-hand corner of the switchboard panel. These are followed by the 102 and 202 and then the 103 and 203 numbers, each group in its own block.

Section	*Ext. No.*
COMMANDING GENERAL (through Secretary)	606
Aide-de-camp (ext. to CG)	613
Visiting General Officers (qtrs.)	106
CHIEF OF STAFF	605
Chief Clerk	605
Deputy Chief of Staff	505
ASSISTANT CHIEF OF STAFF, G–1	601
Administrative and Chief Clerk	101
Enlisted Men's subsection	701
Executive Officer	501
Officers' subsection (Special Services)	801
ASSISTANT CHIEF OF STAFF, G–2	602
Administrative and Chief Clerk	102
Counterintelligence	202
Combat Intelligence	302
Executive Officer	502
Public Information. (*See* under P.)	
ASSISTANT CHIEF OF STAFF, G–3	603
Administrative and Chief Clerk	103
Antiaircraft	703
Executive Officer	503
Test and Inspection	203
Training and Operations	303
ASSISTANT CHIEF OF STAFF, G–4	604
Administrative and Chief Clerk	104
Automotive subsection	804
Construction, Utilities, and Fiscal	304
Executive Officer	504
Supply subsection	404
Transportation and Evacuation (Traffic)	704

Section	Ext. No.
ADJUTANT GENERAL	607
Assistant Adjutant Generals	507
Chief Clerk	607
Classification	207
Classified Records	707
Machine Records	807
Mail and Records	107
Publications	307
AIR OFFICER	614
Chief Clerk	614
ANTIAIRCRAFT. (*See* ASSISTANT CHIEF OF STAFF, G–3.)	
ARTILLERY, CHIEF OF	622
Administrative and Chief Clerk	122
Operations Assistant	322
CHAPLAIN	619
Assistant and Chief Clerk	619
CHEMICAL OFFICER	623
Assistant and Chief Clerk	623
ENGINEER OFFICER	615
Administrative and Chief Clerk	115
Executive Officer	515
General Engineers and Utilities	315
Supply and General Information	415
DUTY OFFICER	607
FINANCE OFFICER	618
Assistant and Chief Clerk	618
Pay and Allowance Clerk	318
HQ COMMANDANT	634
Administrative and 1st Sgt	134
Headquarters Company	734
Supply Officer	434
INSPECTOR GENERAL	609
Assistant and Chief Clerk	609
JUDGE ADVOCATE GENERAL	617
Assistant and Chief Clerk	617
LIAISON OFFICER	624
MACHINE RECORDS. (*See* ADJUTANT GENERAL.)	

Section	Ext. No.
MEDICAL. (*See* SURGEON.)	
MESSAGE CENTER	711
MOTOR OFFICER (and Dispatcher)	735
ORDNANCE OFFICER	608
Administrative and Chief Clerk	108
Ammunition	408
Automotive and Maintenance	708
Executive Officer	508
POSTAL OFFICER	620
Chief Clerk	620
PROVOST MARSHAL	627
Asistant and Chief Clerk	627
Receptionist and/or MP	127
PUBLIC INFORMATION OFFICER	642
PUBLIC TELEPHONE	733
QUARTERMASTER OFFICER	621
Administrative and Chief Clerk	121
Executive Officer	521
Purchase	721
Supply	421
Training	321
Transportation	821
RADIO	728
Radio Transmitters	828
RED CROSS	650
SIGNAL OFFICER	610
Administrative and Chief Clerk	110
Communications and Operations	310
Signal Supply	410
SPECIAL SERVICES. (*See* ASSISTANT CHIEF OF STAFF, G–1.)	
SURGEON	616
Assistant and Chief Clerk	616
Dispensary	716
TELEPHONE CHIEF OPERATOR	731
TELETYPE CHIEF OPERATOR	730
UMPIRE	799

Section	*Ext. No.*
COMMANDING GENERAL	606; 613
Aides-de-camp	606; 613
Chief Clerk	606; 613
CHIEF OF STAFF	605
Aides	705
Chief Clerk	105
Deputy Chief of Staff	505
ASSISTANT CHIEF OF STAFF, G–1	601
Administrative	101
Chief Clerk	101
Enlisted Men's Section	701
Officers' Section	801
School	901
ASSISTANT CHIEF OF STAFF, G–2	602
Administrative	102
Chief Clerk	102
Combat Intelligence	302
Counterintelligence	202
Executive Officer	502
Map and Training	702
ASSISTANT CHIEF OF STAFF, G–3	603
Administrative	103
Chief Clerk	103
Executive Officer	503
Operations	303
Test and Inspection	203
Training	703
Troop Movement	803
ASSISTANT CHIEF OF STAFF, G–4	604
Administrative Officer	104
Chief Clerk	104
Construction	904

Section	Ext. No.
ASSISTANT CHIEF OF STAFF, G–4—Continued	
Executive Officer	504
Fiscal	704
Operations	304
Supply	404
Transportation and Maintenance	804
ADJUTANT GENERAL	607
Administrative and Personnel	107
Chief Clerk	107
Classification	207
Classified Records	707
Executive Officer Miscellaneous	507
Executive Officer Personnel	507
Machine Records	807
Mail and Records	907
Miscellaneous Division	407
Publications	307
AIR OFFICER	614
AMMUNITION OFFICERS	625
ANTIAIRCRAFT OFFICER	641
ARTILLERY OFFICER	622
Chief Clerk	122
Executive Officer	522
Intelligence	222
Personnel	122
Supply	422
Training and Operations	322
CHAPLAIN	619
CHEMICAL OFFICER	623
Administrative	123
Chief Clerk	123
DISPATCHER	735
Motor Cars	735
Trucks	835
ENGINEER OFFICER	615
Administrative and Personnel	115
Chief Clerk	115
Executive Officer	515
General Construction	815

Section	Ext. No.
ENGINEER OFFICER—Continued	
Intelligence and Maps	215
Operations and Training	315
Roads	715
Transportation and Supply	415
FINANCE OFFICER	618
Administrative	118
Assistant Finance Officer	618
Chief Clerk	118
Fiscal and Accounting	418
Officers' Pay and Allowances	318
HEADQUARTERS COMMANDANT	634
Assistant	534
Chief Clerk (Administrative and Personnel)	134
Headquarters Company	734
Supply Officer	434
INSPECTOR GENERAL	609
Administrative	109
Chief Clerk	109
Inspection	309
Investigation	209
JUDGE ADVOCATE	617
Administrative	117
Assistant	617
Chief Clerk	117
LIAISON OFFICERS	624
MEDICAL DISPENSARY	716
MESSAGE CENTER	711
MOTOR DISPATCHER. (*See* DISPATCHER.)	
ORDNANCE OFFICER	608
Administrative and Personnel	108
Chief Automotive Adviser	808
Chief Clerk	108
Executive Officer	508
General Supply	408
Maintenance	708
Operations	308
Weapons Maintenance	908
PHOTO LABORATORY (THIRD ARMY)	880

Section	Ext. No.
POSTAL OFFICER	620
PROVOST MARSHAL	627
Military Police	127
MP Information Desk	227
PUBLIC INFORMATION OFFICER	642
Assistants to Public Information Officer	642
Chief Clerk	142
PUBLIC TELEPHONE No. 1	733
PUBLIC TELEPHONE No. 2	833
QUARTERMASTER OFFICER	621
Administrative	121
Chief Clerk	121
Executive Officer	521
Inspection	221
Personnel	821
Plans and Training	321
Purchasing and Contracting	721
Supply Division	421
Transportation Division (Rail)	921
RADIO STATION	728
Radio Transmitters	828
RED CROSS	650
SIGNAL OFFICER	610
Administrative and Personnel	110
Chief Clerk	110
Communications and Operations	310
Executive Officer	510
Signal Intelligence Service	210
Supply	410
Training	710
SPECIAL SERVICE OFFICER	637
Assistants	537
Chief Clerk	137
SURGEON	616
Chief Clerk	116
Consultant	716
Dental	816
Executive Officer	516

	Section	*Ext. No.*
SURGEON—Continued		
Operations and Training		316
Personnel		116
Preventive Medicine		916
Supply		416
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